Boosting Enterprise Transaction Processing using Hardware Acceleration

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IBM Research & Development
Böblingen, Germany

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Agenda

• IBM LinuxONE System

• Future Trends/Requirements and LinuxONE

• Hardware Acceleration Support on IBM LinuxONE
  – Compression with zEDC card
  – Encryption with CPACF and CEX5S

• Concluding Remarks
IBM LinuxONE
Combination of Enterprise and Linux

Availability
Low unplanned downtime

Scalability
- Scale-out with virtualization
- Scale-up for large apps/data

Performance
- High I/O throughput
- 4 levels of cache

Security
- Dedicated crypto processors
- Crypto Cards

Reliability
- Embedded error detection
- Disaster recovery

Freedom

Customization
- Optimize aspects of Kernel

Innovation
- High uptimes
- Regular updates
- Worldwide community

Stability

Software Quality
- Multitude of choices
- Quick/self updates for open-source

Flexibility

- Freedom
- Customization
- Innovation
- Stability
- Software Quality
- Flexibility
LinuxONE Architecture

• Cores:
  – Up to 141 cores with SMT

• Memory:
  – Up to 10 TB

• LPAR: Logical Partition
  – Subset of hardware resources virtualized as a separate computer with a running Linux OS, up to 85

• Virtualization
  – Linux guests under KVM or z/VM, thousands possible
  – Thousands of Docker containers possible
IBM LinuxONE

Open Source & ISV Ecosystem

Distributions
- Supported Versions
  - ubuntu
  - SUSE
  - redhat
  - CentOS

Community Versions
- debian
- openSUSE
- fedora

Hypervisors
- KVM
- LPAR

Languages
- python
- Ruby
- PHP
- ERLANG
- Scala
- Clojure
- JS

Runtimes
- nodeJS
- rails
- chef
- puppet
- OpenJDK
- OCaml
- Java

Management
- docker
- MariaDB
- PostgresSQL
- Spark
- chef
- puppet
- docker
- mongodb
- hadoop
- juju
- cassandra
- elasticsearch
- openstack
- Vmware
- vRealize

Database
- DB2

Analytics
- Oracle
- IBM InfoSphere
- BigInsights
- IBM Infosphere BigInsights
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Future Trends

Global Internet Traffic in PB per Month

Current business infrastructures must be highly reliable, able to cope with high traffic, provide high security to their clients, and enable high availability.

IoT by 2020:
- ~30 billion devices will be connected to the networks and possibly to each other
- 28x more sensor-enabled devices than population of the earth

Average cost of a data breach is $3.8 – $4 million US dollars! **

## Future Requirements and LinuxONE

<table>
<thead>
<tr>
<th>High Availability</th>
<th>Low Unplanned Downtime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Non-disruptive upgrades, installation, maintenance</td>
</tr>
<tr>
<td></td>
<td>- “Spare” cores can be turned ON without program interruption</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Highly Reliable</th>
<th>Embedded Error Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Built-in, automated diagnostics, problem identification and isolation</td>
</tr>
<tr>
<td>Disaster Recovery</td>
<td>like GDPS appliance</td>
</tr>
<tr>
<td>Built-in Redundancy</td>
<td>to eliminate single-point-of-failures</td>
</tr>
</tbody>
</table>

| High Security      | - FIPS 140-2 Level 4 certified cryptographic hardware |
|--------------------| - Dedicated crypto cards |

| Processing Power   | - 141 cores, 5GHz clock frequency, 960MB L4 cache |
|--------------------| - Dedicated I/O processors |
|                    | - Hardware accelerators |
Agenda

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Hardware Acceleration Support

- **Compression**
  - CMPSC compression coprocessor
  - Enterprise Data Compression (zEDC) card
- **Encryption**
  - CP Assist for Cryptographic Function (CPACF)
  - Crypto Express Card (CEX)
- **I/O**
  - OSA-Express card, RoCE cards
  - Flash-Express, FICON-Express cards
Compression

• Why use compression?
  – 2.5 quintillion \((2.5 \times 10^{18})\) bytes of data generated per day!
  – Constrained I/O bandwidths
  – Finite storage solutions

• Why avoid compression?
  – Processing power is consumed
  – Energy/battery is consumed
  – Read requires a decompression

Don’t compress frequently accessed data with limited hardware resources
zEDC Compression Card

- PCIe adapter based compression card
- Shareable among 15 LPARs
- Compatible with:
  - zlib
  - Java via java.util.zip
- Provides Customized:
  - Compatible libz.so and API to switch between hardware (zEDC) and software compression transparently from the program
  - gzip/gunzip etc. tools (genwqe_gzip/genwqe_gunzip)
- Interface similar to zlib
- Buffering and SW/HW switching
- libcard provides C-style APIs to the device driver

- Serialize requests to the card
- Enables multi-guest and multi-process usage
- Exposes sysfs and debugfs interfaces
zEDC Compression Card

• Advantages
  – Up to 1 GB/s raw throughput vs 50 MB/s in software
  – Up to 4x data compression → 75% disk saving/link bandwidth savings
  – Minimal CPU overhead, low latency

• Use-Cases
  – Database backup and restore
  – Large files/data transfer over limited bandwidth
  – Cross platform data exchange
  – Batch processing jobs
Compressed DB:

- Low storage
- Quick transfer
- High complexity
- Less robust
DB2 LUW Backup and Restore

- **DB2 Database Backup**
  - No compression: No compression engine used, **least CPU**, large backup size
  - Software compression: High CPU, **small backup size**
  - Hardware compression (using zEDC card on LinuxONE): **Low CPU**, small/medium backup size

- **Multiple User Options**
  - PARALLELISM <n>: Number of table spaces which can be read in parallel
  - COMPRLIB <name>: Name of the library used for compression

- `db2 backup db db_name to backup_loc PARALLELISM parallelism_val compress comprlib library_name`
# DB2 LUW Backup and Restore

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<thead>
<tr>
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<th>x86 Platform</th>
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<td>System</td>
<td>1 LPAR</td>
<td>Dedicated Server</td>
</tr>
<tr>
<td>Cores</td>
<td>32 dedicated with SMT</td>
<td>36, with HT</td>
</tr>
<tr>
<td>Memory</td>
<td>768 GB</td>
<td>768 GB</td>
</tr>
<tr>
<td>OS</td>
<td>RHEL – 7.2</td>
<td>RHEL – 7.2</td>
</tr>
<tr>
<td>DB2 Version</td>
<td>DB2 v11.1</td>
<td>DB2 v11.1</td>
</tr>
<tr>
<td>Database</td>
<td>TPCC (Hammer-DB)</td>
<td>TPCC (Hammer-DB)</td>
</tr>
<tr>
<td>Database Size</td>
<td>385 GB</td>
<td>385 GB</td>
</tr>
<tr>
<td>Storage</td>
<td>IBM System Storage DS8000</td>
<td>IBM System Storage DS8000</td>
</tr>
</tbody>
</table>
Running DB2 v11.1 backup on LinuxONE Emperor with zEDC card is up to 15x faster than on a compared x86 platform using software compression.

Faster backup could mean shorter maintenance windows

Disclaimer: Performance results based on IBM internal tests running database backup with compression on DB2 v11.1 to /dev/null. Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.30GHz, 1-8 cores enabled for DB2 v11.1, 768 GB memory, and 80 GB local RAID-5 volume on 15K 12 Gbps SAS drives, RHEL 7.2, 385 GB database on IBM DS8800. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, 1-8 cores enabled for DB2 v11.1, 768 GB memory, and 40 GB DASD storage. RHEL 7.2 with SMT, 385 GB database on IBM DS8800.
Running DB2 v11.1 backup on LinuxONE Emperor with zEDC utilizes up to 62% lesser CPU than on a compared x86 platform using software compression.

More resources can be allocated to parallel running processing.

Disclaimer: Performance results based on IBM internal tests running database backup with compression on DB2 v11.1 to /dev/null. Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.30GHz, 1-8 cores enabled for DB2 v11.1, 768 GB memory, and 80 GB local RAID-5 volume on 15K 12 Gbps SAS drives, RHEL 7.2, 385 GB database on IBM DS8000. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, 1-8 cores enabled for DB2 v11.1, 768 GB memory, and 40 GB DASD storage, RHEL 7.2 with SMT, 385 GB database on IBM DS8000.
Running DB2 v11.1 restore on LinuxONE Emperor with zEDC card is up to 2.3x faster than on a compared x86 platform using software compression.

Running DB2 v11.1 restore on LinuxONE Emperor with zEDC card utilizes up to 77% lesser CPU than a compared x86 platform using software compression.

Disclaimer: Performance results based on IBM internal tests running database restore with compression on DB2 v11.1. Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.60 GHz, 1-8 cores enabled for DB2 v11.1, 768 GB memory, and 80 GB local RAID-5 volume on 15K 12 Gbps SAS drives, RHEL 7.2, 385 GB database and backup on IBM DS8000. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, 1-8 cores enabled for DB2 v11.1, 768 GB memory, and 40 GB DASD storage, RHEL 7.2 with SMT, 385 GB database and backup on IBM DS8000.
MongoDB Backup (Dump)

- **Dump Database**
  - No compression: No compression engine used, **least CPU**, large dump size
  - Software compression: High CPU, **small dump size**
  - Hardware compression (using zEDC card on LinuxONE): **Low CPU**, small/medium dump size
MongoDB Backup

• Options
  – gzip: Compress the dump via gzip tool
    • Single threaded → use pigz for software, genwqe_gzip for zEDC
  – archive: Push to stdout (in order to use pigz or genwqe_gzip)

• mongodump --host name --port mongod_port --db db_name --archive | pigz -p pigz_threads > output_file
• mongodump --host name --port mongod_port --db db_name --archive | genwqe_gzip > output_file
## MongoDB Backup and Restore

<table>
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<th>x86 Platform</th>
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</thead>
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<td>System</td>
<td>1 LPAR</td>
<td>Dedicated Server</td>
</tr>
<tr>
<td>Cores</td>
<td>32 dedicate with SMT</td>
<td>36, with HT</td>
</tr>
<tr>
<td>Memory</td>
<td>768 GB</td>
<td>768 GB</td>
</tr>
<tr>
<td>OS</td>
<td>RHEL – 7.2</td>
<td>RHEL – 7.2</td>
</tr>
<tr>
<td>MongoDB Version</td>
<td>Enterprise v3.3</td>
<td>Enterprise v3.2</td>
</tr>
<tr>
<td>Database Size</td>
<td>83 GB</td>
<td>83 GB</td>
</tr>
<tr>
<td>Storage</td>
<td>IBM System Storage DS8000</td>
<td>IBM System Storage DS8000</td>
</tr>
</tbody>
</table>
MongoDB Backup Performance

Running MongoDB Enterprise v3 dump on LinuxONE Emperor with zEDC is up to 3.8x faster than on a compared x86 platform using software compression.

Disclaimer: Performance results based on IBM internal tests running database dump with compression on MongoDB Enterprise Release (Database size 83 GB). Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.3GHz, 1-8 cores enabled, 768 GB memory, and 80 GB local RAID-5 volume on 15K 12 Gbps SAS drives, RHEL 7.2, database and backup on IBM DS8000, MongoDB Enterprise Release 3.2, pigz version 2.3.3. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, 1-8 cores enabled, 768 GB memory, 40 GB DASD storage, RHEL 7.2 with SMT, database and backup on IBM DS8000, MongoDB Enterprise Release 3.3, genwqe-user-4.0.17.
Running MongoDB Enterprise v3 dump on LinuxONE Emperor with zEDC card utilizes up to 74% lesser CPU than on a compared x86 platform using software compression.

MongoDB Backup CPU Utilization

Disclaimer: Performance results based on IBM internal tests running database dump with compression on MongoDB Enterprise Release (Database size 83 GB). Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.30GHz, 1-8 cores enabled, 768 GB memory, and 80 GB local RAID-5 volume on 15K 12 Gbps SAS drives, RHEL 7.2, database and backup on IBM DS8000, MongoDB Enterprise Release 3.2, pigz version 2.3.3. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, 1-8 cores enabled, 768 GB memory, 40 GB DASD storage, RHEL 7.2 with SMT, database and backup on IBM DS8000, MongoDB Enterprise Release 3.3, genwqe-user-4.0.17.
MongoDB Restore Performance

**MongoDB Restore Time**

![Time comparison chart](chart.png)

**MongoDB Restore CPU Util.**

![CPU utilization chart](chart.png)

Running MongoDB Enterprise v3 restore on LinuxONE Emperor with zEDC card is up to **18% faster** than on a compared x86 platform using software decompression.

Disclaimer: Performance results based on IBM internal tests running database restore with compression on MongoDB Enterprise Release (database size 83 GB). Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.30GHz, 1-8 cores enabled, 768 GB memory, and 80 GB local RAID volume on 15x 12 Gbps SAS drives, RHEL 7.2, database and backup on IBM DS8000, MongoDB Enterprise Release 3.2, pigz version 2.3.3. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, 1-8 cores enabled, 768 GB memory, 40 GB DASD storage, RHEL 7.2 with SMT, database and backup on IBM DS8000, MongoDB Enterprise Release 3.3, genwqe-user-4.0.17.
**Sharding**: A single chunked DB is converted into smaller chunks and distributed over different machines.

**Replication**: A DB is copied to another location for reliability, accessibility, availability and fault-tolerance.

**Sharded (Multi-Node) MongoDB Backup**

- **Sharded DB**:
  - 😊 Storage scaling
  - 😊 Memory scaling
  - 😊 CPU scaling
  - 😊 Robustness
  - 😞 Increased complexity
  - 😞 Management

**Database**

**Server 0**
- Shard 0 Primary
- Shard 3 Secondary
- Shard 2 Arbiter

**Server 1**
- Shard 1 Primary
- Shard 0 Secondary
- Shard 3 Arbiter

**Server 2**
- Shard 2 Primary
- Shard 1 Secondary
- Shard 0 Arbiter

**Server 3**
- Shard 3 Primary
- Shard 2 Secondary
- Shard 1 Arbiter

Lock these replica-sets and take their dump.
## Sharded MongoDB Config

<table>
<thead>
<tr>
<th>Config</th>
<th>LinuxONE</th>
<th>x86 Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>4 LPARs on one LinuxONE</td>
<td>4 dedicated servers</td>
</tr>
<tr>
<td>Cores per LPAR/server</td>
<td>12 dedicate with SMT</td>
<td>12, with HT</td>
</tr>
<tr>
<td>Memory per LPAR/server</td>
<td>512 GB</td>
<td>512 GB</td>
</tr>
<tr>
<td>OS</td>
<td>RHEL – 7.2</td>
<td>RHEL – 7.2</td>
</tr>
<tr>
<td>MongoDB Version</td>
<td>Enterprise v3.2</td>
<td>Enterprise v3.2</td>
</tr>
<tr>
<td>Database Size</td>
<td>400 GB</td>
<td>400 GB</td>
</tr>
<tr>
<td>Collections</td>
<td>4, 100 GB each</td>
<td>4, 100 GB each</td>
</tr>
<tr>
<td>DB Location</td>
<td>IBM FlashSystem 900</td>
<td>Local SSDs</td>
</tr>
</tbody>
</table>
Running MongoDB Enterprise v3.2 dump on LinuxONE Emperor with zEDC card on 4 shards in parallel is **1.7x faster** than on a compared x86 platform using software compression.

Disclaimer: Performance results based on IBM internal tests running database dump with compression on MongoDB Enterprise Release (YCSB database size 400 GB, with 4 collections of 100 GB each, 100 GB DB per shard). Results may vary. x86 config per server: Intel E5-2690 v3 cores @ 2.60GHz servers, 12 cores enabled, 512 GB memory, RHEL 7.2, database on local 1.7 TB SSDs, MongoDB Enterprise Release 3.2, pigz version 2.3.3. LinuxONE config: 4 LinuxONE Emperor LPARs, each LPAR with: 12 dedicated cores, 512 GB memory, 40 GB DASD storage, RHEL 7.2 with SMT, database on IBM FlashSystem 900, MongoDB Enterprise Release 3.2, pigz version 2.3.3, genwqe user-4.0.17.
Cryptography

• Why use encryption?
  – Safeguard personal identity and privacy
  – Protecting sensitive data

• When to avoid encryption?
  – Maybe the fear of losing your password 😊
Crypto Acceleration in LinuxONE

- **CPACF – CP Assist for Cryptographic Functions**
  - Designed to improve performance of crypto functions
  - Symmetric cryptography, secure hashing

- **CEX5S – Crypto Express5S Card**
  - PCIe Cryptographic Coprocessor (PCIeCC)
  - Hardware to perform AES, DES, T-DES, HMAC, random number generation, SHA-1, SHA-256, SHA-384, SHA-512, MD5, HMAC, and large number modular math functions for RSA (up to 4096-bit), ECC Prime Curve and other public-key cryptographic algorithms
End-to-End Encryption:
- JMeter ↔ Apache
- Apache ↔ Acmeair
- Acmeair ↔ MongoDB

Encryption Libraries

Apache HTTPD (Load Balancer)

Acme Air (Node.js App)

Acme Air (Node.js App)

Acme Air (Node.js App)

Acmeair [Node.js + MongoDB] Application Server(s)

Mongo Database

10 Gbps Network
## Acme Air [Node.js + MongoDB] Config

<table>
<thead>
<tr>
<th>Config</th>
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<td>System</td>
<td>1 LPAR</td>
<td>Dedicated Server</td>
</tr>
<tr>
<td>Cores</td>
<td>32 dedicated with SMT</td>
<td>36, with HT</td>
</tr>
</tbody>
</table>
| Core Assignment | **Apache**: 1  
**Node.js**: 1, 2, 4, 8, 16  
**MongoDB**: 2 if Node.js 1, 2 or 4 4 if Node.js 8 or 16 | **Apache**: 1  
**Node.js**: 1, 2, 4, 8, 16  
**MongoDB**: 2 if Node.js 1, 2 or 4 4 if Node.js 8 or 16 |
| Memory          | 768 GB                          | 768 GB                        |
| OS              | RHEL – 7.2                      | RHEL – 7.2                    |
| MongoDB Version | Enterprise v3.3                 | Enterprise v3.2               |
| JMeter Version  | 2.13                            | 2.13                          |
| DB Location     | RAM disk                        | RAM disk                      |
Running Acme Air application with end-to-end encryption on LinuxONE Emperor is up to 1.9x faster than on a compared x86 platform with end-to-end encryption.

Disclaimer: Performance results based on IBM internal tests running Acme Air with 10,000 customers on Node.js v6.1 against MongoDB Enterprise v3.3 driven remotely by 250 JMeter 2.13 threads. Apache HTTP server v2.4.6 was used as load balancer. TLS v1.2, DHE-RSA-AES128-GCM-SHA256 cipher was used between JMeter and Apache HTTP, ECDHE-RSA-AES128-GCM-SHA256 cipher was used between Apache HTTP and Node.js, RSA 4096 bit key for SSL configuration of MongoDB. Results may vary. x86 config: 36 Intel ES-2699 v3 cores @ 2.30GHz, Apache HTTP server pinned to 1 core, Node.js pinned to 1-16 cores, MongoDB pinned to 2-4 cores, 768GB memory, and 80 GB local RAID-5 volume on 15X 12 Gbps SAS drives, RHEL 7.2, OpenSSL 1.0.1e-fips 11 Feb 2013, application logs and database on the RAM disk. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, Apache HTTP server pinned to 1 core, Node.js pinned to 1-16 cores, MongoDB pinned to 2-4 cores, 768GB memory, 40 GB DASD storage, RHEL 7.2 with SMT, OpenSSL 1.0.1e-fips 11 Feb 2013, application logs and database on the RAM disk.
WebSphere Application Sever (WAS)

- **Application Middleware**
  - Provides tools to create and integrate applications
  - Hosts Java based web applications

<table>
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<td>System</td>
<td>1 LPAR</td>
<td>Dedicated Server</td>
</tr>
<tr>
<td>Cores</td>
<td>2 – 16 dedicated cores, SMT</td>
<td>2 – 16 cores, HT</td>
</tr>
<tr>
<td>Memory</td>
<td>768 GB</td>
<td>768 GB</td>
</tr>
<tr>
<td>OS</td>
<td>RHEL – 7.2</td>
<td>RHEL – 7.2</td>
</tr>
<tr>
<td>WebSphere Version</td>
<td>v8.5.5.9</td>
<td>v8.5.5.9</td>
</tr>
<tr>
<td>DB2 Version</td>
<td>v10.5.7</td>
<td>v10.5.7</td>
</tr>
<tr>
<td>Java Version</td>
<td>v1.8</td>
<td>v1.8</td>
</tr>
<tr>
<td>DayTrader Version</td>
<td>v3</td>
<td>v3</td>
</tr>
</tbody>
</table>
Running WebSphere Application Server 8.5.5.9 with encryption on LinuxONE Emperor provides up to 2.1x more throughput than on a compared x86 platform with encryption.

Disclaimer: Performance results based on IBM internal tests running DayTrader v3 with 15000 users on WebSphere Application Server (WAS) v8.5.5.9 driven remotely by JMeter v2.12. DB2 LUW v10.5.7 was used as database system. Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.30GHz, WAS pinned to 1-8 cores, DB2 pinned to 1-8 cores, number of DB2 cores equals number of WAS cores, 768GB memory, and 80 GB local RAID-5 volume on 15K 12 Gbps SAS drives, RHEL 7.2, 177 MB database on local HDDs, IBM Java 1.8.0 (SR2). JMeter threads was 4 times number of WAS cores. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, WAS pinned to 1-8 cores, DB2 pinned to 1-8 cores, number of DB2 cores equals number of WAS cores, 768GB memory, 177 MB DB2 database on 40 GB DASD storage, RHEL 7.2 with SMT, IBM Java 1.8.0 (SR2). JMeter threads was 2 times number of WAS cores.
Apache HTTP with Crypto Express5S (CEX5S) Card

- **Apache HTTP Server utilizing CEX5S**
  - Enabled by using IBM proprietary library “libica”

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</tr>
<tr>
<td>Cores</td>
<td>2 dedicated, SMT</td>
<td>2, with HT</td>
</tr>
<tr>
<td>Memory</td>
<td>768 GB</td>
<td>768 GB</td>
</tr>
<tr>
<td>OS</td>
<td>RHEL – 7.2</td>
<td>RHEL – 7.2</td>
</tr>
<tr>
<td>Apache Version</td>
<td>v2.4.6</td>
<td>v2.4.6</td>
</tr>
<tr>
<td>Apache Bench</td>
<td>v2.3</td>
<td>v2.3</td>
</tr>
<tr>
<td>Webpage Size</td>
<td>1024 Bytes</td>
<td>1024 Bytes</td>
</tr>
</tbody>
</table>
Running Apache HTTP v2.4.6 on LinuxONE Emperor with Crypto Express5S card achieves up to 2.6x more throughput than on a compared x86 platform using software encryption.

Disclaimer: Performance results based on IBM internal tests running 32 Apache Bench 2.3 instances (each with 250 users) remotely via 10 Gbps network against Apache HTTP v2.4.6 using 1024 bytes html page, TLS v1.2, OpenSSL 1.0.1e-fips 11 Feb 2013. Results may vary. x86 config: 36 Intel E5-2699 v3 cores @ 2.30GHz, 2 cores enabled for Apache HTTP, 768GB memory, and 80 GB local RAID-5 volume on 15K 12 Gbps SAS drives, RHEL 7.2. LinuxONE config: LinuxONE Emperor LPAR with 32 dedicated cores, 2 cores enabled for Apache HTTP, 768GB memory, and 40 GB DASD storage, RHEL 7.2 with SMT.
Agenda

• IBM LinuxONE System

• Future Trends/Requirements and LinuxONE

• Hardware Acceleration Support on IBM LinuxONE
  – Compression with zEDC card
  – Encryption with CPACF and CEX5S

• Concluding Remarks
Concluding Remarks

• New/future businesses must be developed with consideration of the future constraints and requirements
• IBM LinuxONE system in collaboration with hardware accelerators can provide high throughput and security
• Database maintenance windows and load on the system can be reduced using zEDC compression card
• Encryption performance can be boosted by exploiting the hardware acceleration support provided by CPACF and CEX5S
Thank you!
## Trademarks

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<table>
<thead>
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<th>Trademark</th>
<th>Description</th>
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<tbody>
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</tr>
<tr>
<td>DS8000*</td>
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<tr>
<td>ECKD</td>
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<tr>
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