The Gold Standard for Enterprise Computing

Unique Innovations That Make zEnterprise Superior

Today's agenda

60 mins	Unique Innovations that make zEnterprise Superior
60 mins	Business Analytics on the Ultimate Data Platform
15 mins	*Break*
60 mins	Dynamic Cloud with zEnterprise
60 mins	*Lunch*
60 mins	Is Your Enterprise Ready for the Mobile Revolution?
60 mins	Mainframe Skills – The Myths and the Reality
15 mins	*Break*
60 mins	Innovative Workloads for zEnterprise

Fifty years ago, IBM introduced the first mainframe computer…

System 360 – April 7, 1964

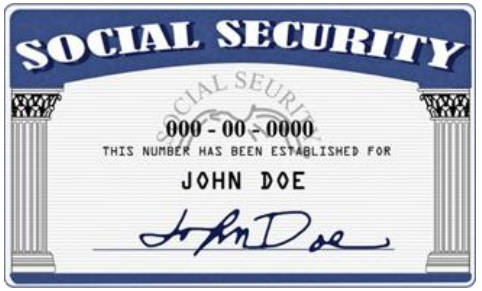
It was revolutionary…

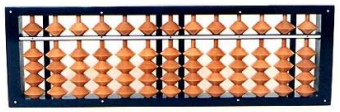
It was innovative…

It changed the world!

It helped put men on the moon…

It touches all of us from the day we were born…





It changed the way we live and work…

Source: IBM

Fifty years ago, IBM introduced the first mainframe computer…

System 360 – April 7, 1964

mi… 5150 – c.1981

NO!!
IBM continues to invest $BILLIONS in mainframe technology

It is still revolutionary…

It is still innovative…

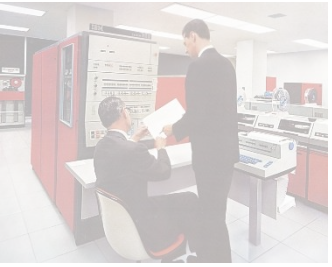
It is still changing the world!

Customer demand and technical leadership have lead to *continuous* re-invention of the mainframe

Hardware carry-forward + continuous application compatibility

S/360 — 1964

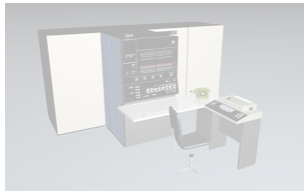
- 24-bit addressing (32-bit architecture)
- 1 or 2 cores
- 16MB storage
- 24K core memory



- VM operating system

S/370 — 1970

- 24-bit or 31-bit virtual addressing
- Fully integrated monolithic memory
- 256 channel architecture
- Virtual storage



- MVS, IMS, CICS, and DB2

S/390 — 1990

- CMOS processors
- More than 1,000 MIPS
- Parallel sysplex
- Enterprise Systems Architecture (ESA)

zSeries — 2000

- Specialty engines
- Hardware-assisted compression and encryption
- Decimal floating point
- 64-bit superscalar architecture

- WebSphere

zEnterprise — 2010

- zEC12: up to 120 cores, 5.5GHz speed, 78,000+ MIPS
- zBC12 for mid-range
- RAIM and Hardware Transactional Memory
- DB2 Analytics Accelerator

- Rational Development & Test

The IBM zEnterprise server – ready for the business challenges of today and the future

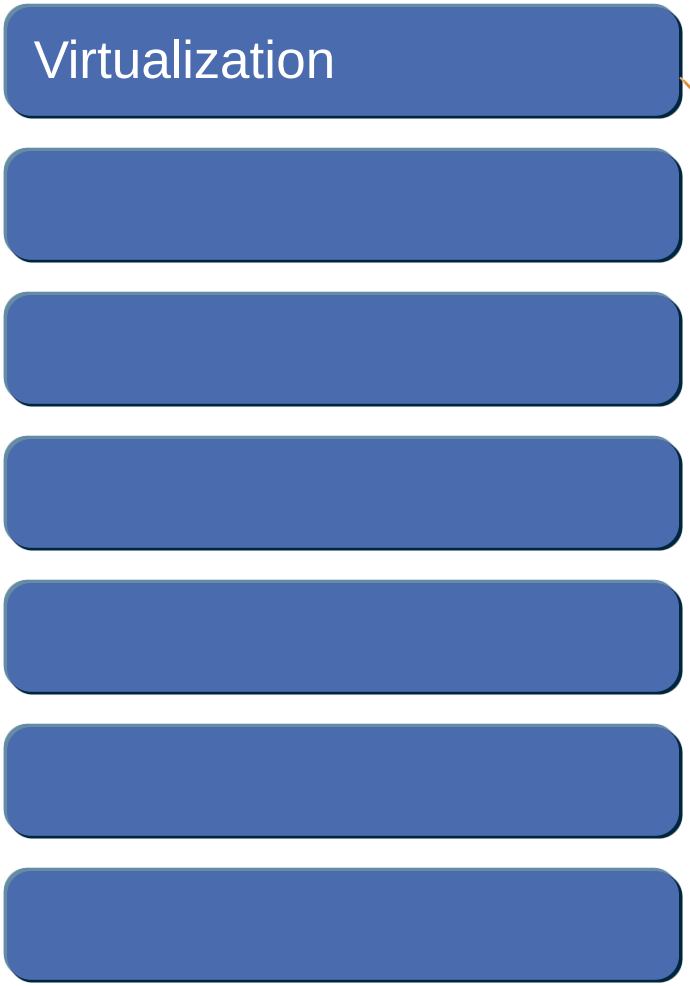
IBM zEnterprise EC12

IBM zEnterprise BC12

- The most available and secure platform commercially available
- Supports today's newest workloads
  - Data and analytics
  - Cloud
  - Mobile
- A multi-architecture platform for hybrid workloads
- Lowest total cost of ownership for most enterprise workloads

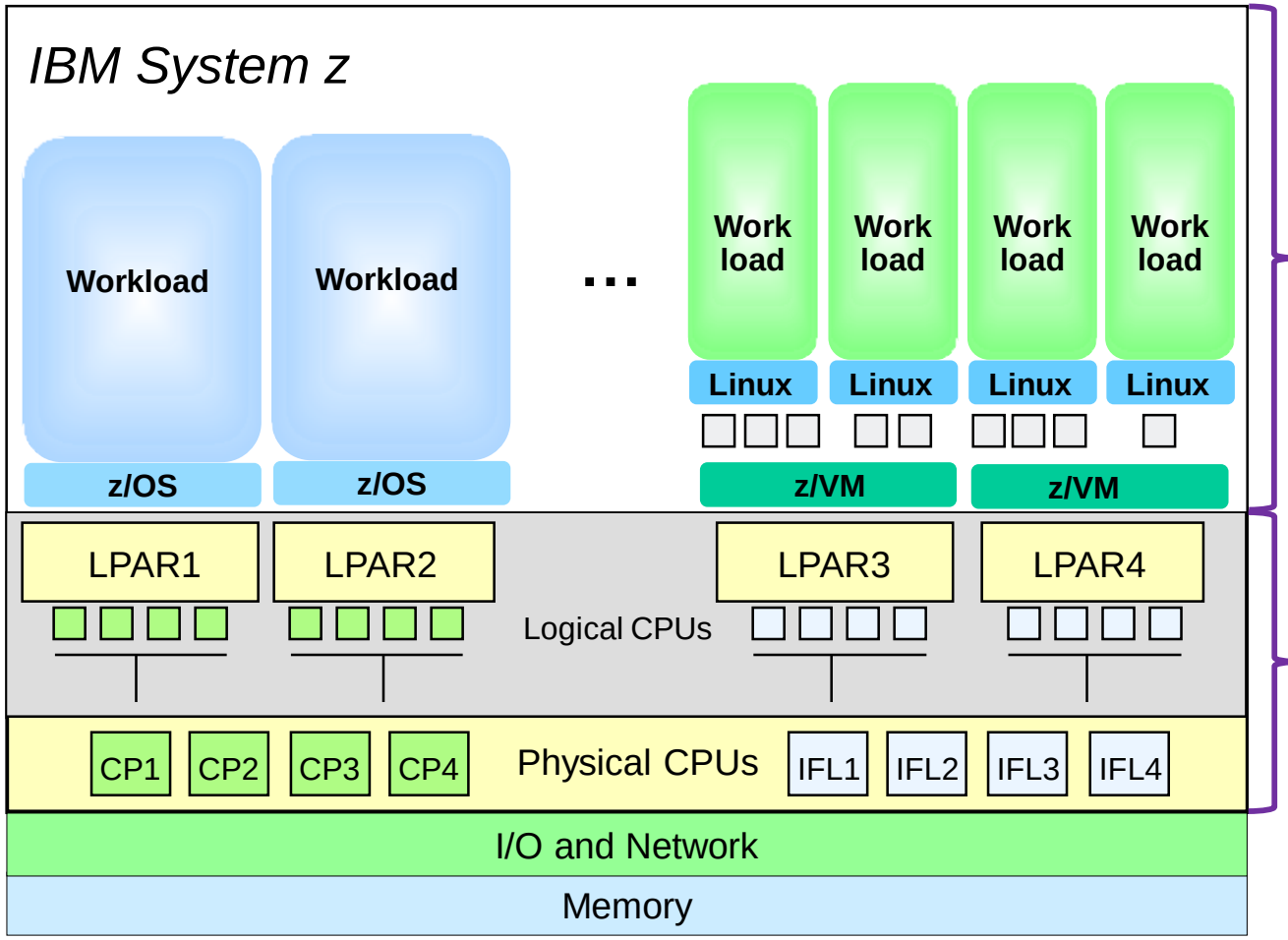
Let's look at some of the key mainframe innovations…

The IBM mainframe was the world's first virtualized server



- Shared-everything design
- Virtualization built into the microcode
- Thousands of virtual guests
- Near 100% utilization
- Ideal choice for cloud deployments

IBM System z virtualization is built-in, not added-on, to give the best workload isolation



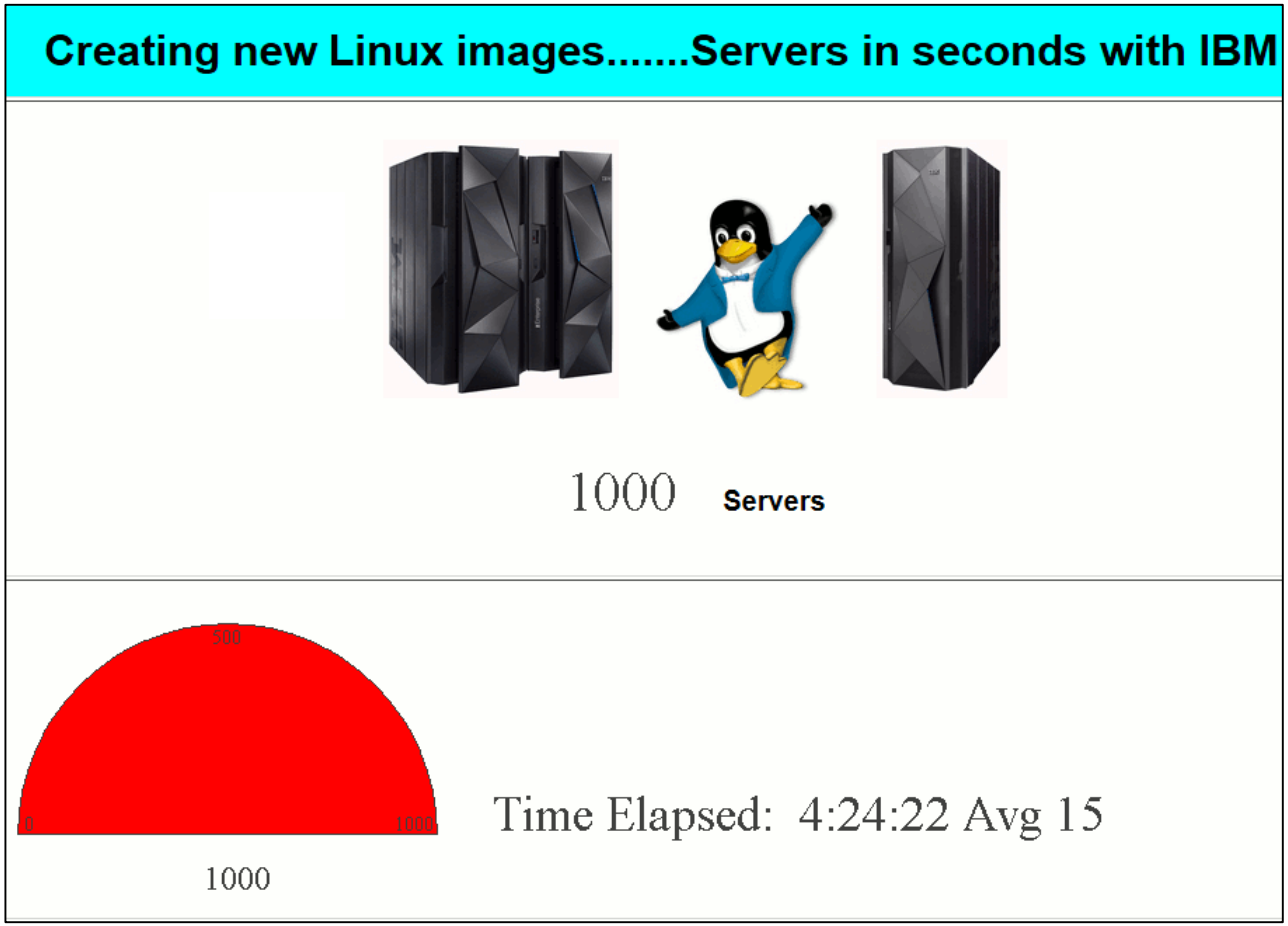
z/VM – a **software** virtualization hypervisor layer supporting 1,000s of Linux guests; up to 32 physical IFLs per z/VM LPAR

PR/SM – virtualization hypervisor layer in **firmware**; each **LPAR** is 1 operating system; workloads in LPARs are completely **isolated**

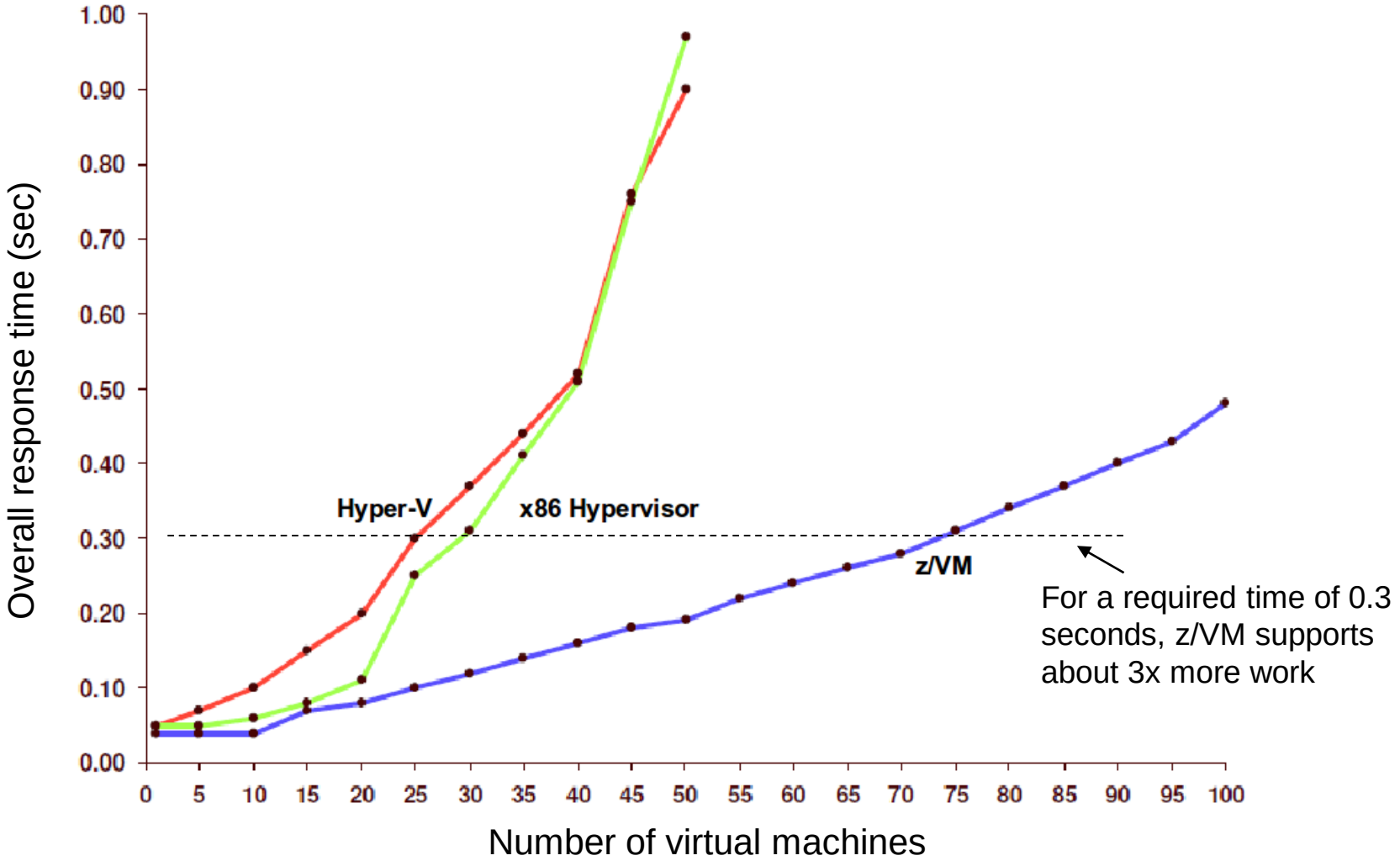
Shared-everything architecture

Hardware-enforced isolation: 10% of circuits support virtualization

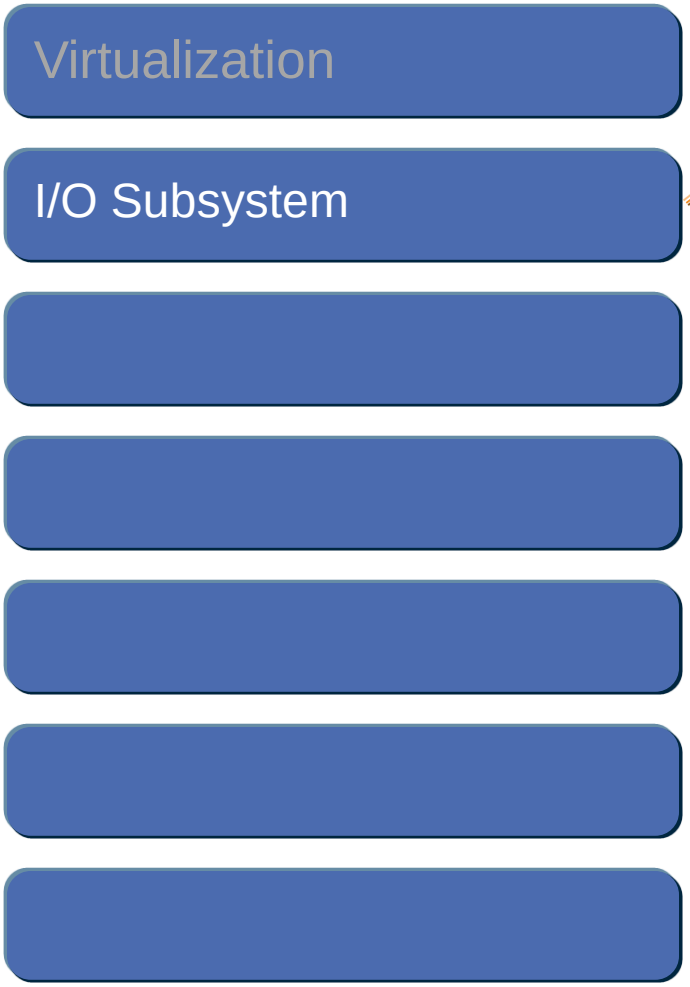
DEMO: How many virtual machines can zEnterprise create?



Compared to leading distributed hypervisors, z/VM demonstrates better scalability

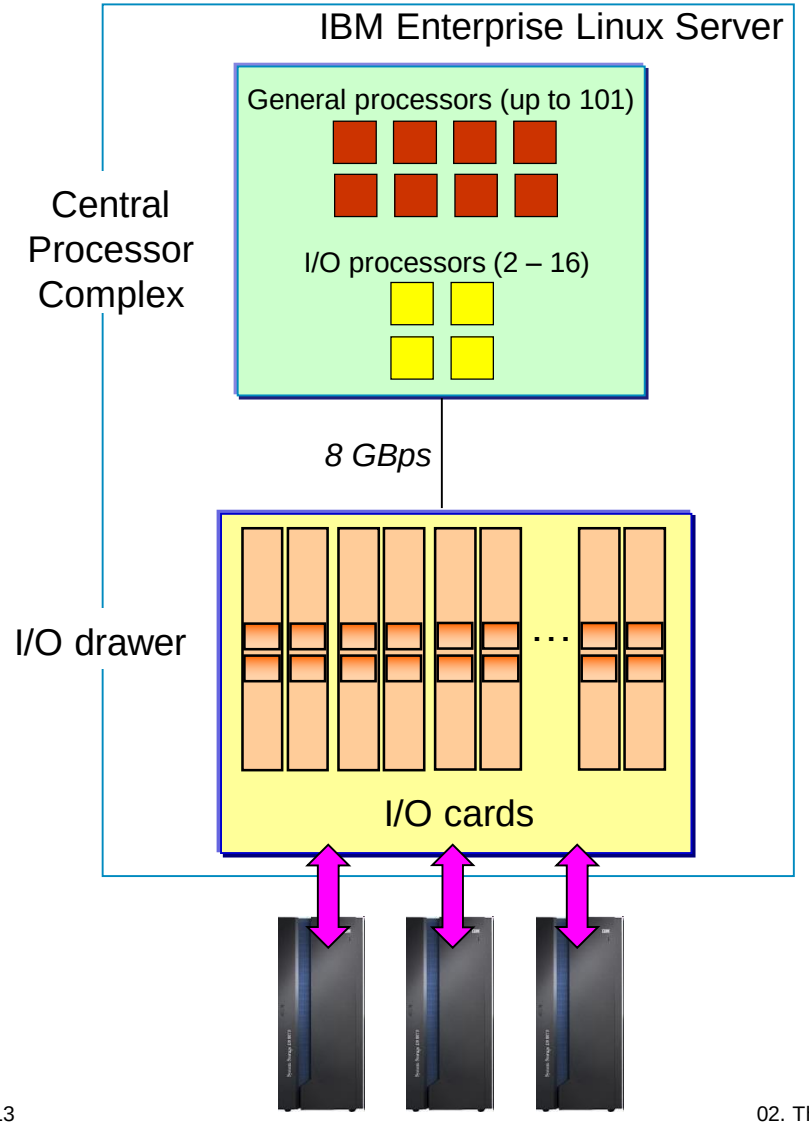


A unique zEnterprise feature not found on other servers is the I/O subsystem



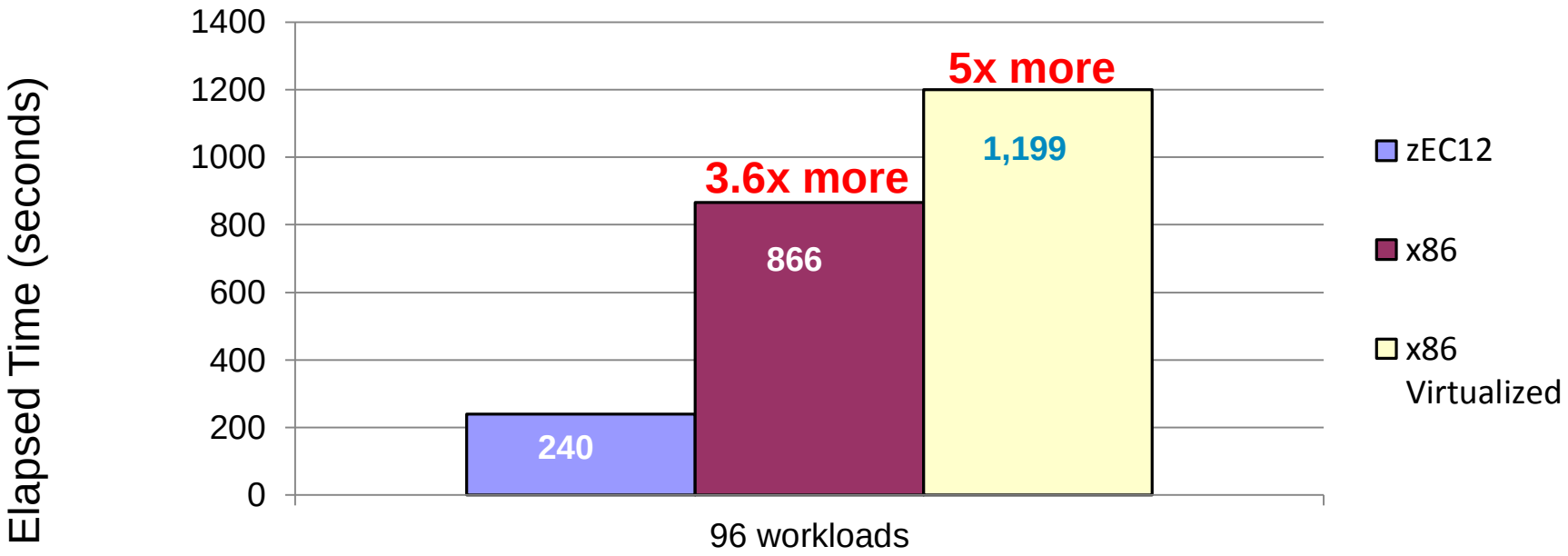
- Reduces CPU usage by offloading I/O overhead
- Reduces number and cost of software licenses
- Improves I/O performance for batch and high performance OLTP
- Allows introduction of new facilities into existing I/O subsystem

zEnterprise includes special processors dedicated to driving I/O



- I/O processing logic is offloaded to special processors
  - Isolates general processing cores for business logic
- I/O processors manage Logical I/O Channel Subsystem
  - Determines optimal physical I/O path to be used
  - Delivers optimized I/O efficiency
- Dedicated I/O subsystem is excellent for high I/O workloads, such as Batch and OLTP
- Intel servers have no dedicated I/O subsystem

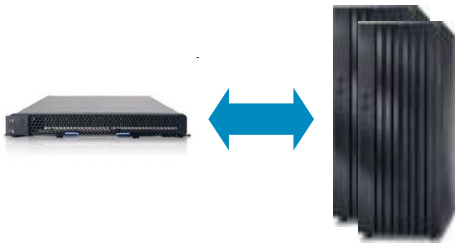
In comparison tests of I/O load capacity, Intel times were significantly slower



Performance comparison test of an I/O intensive workload with identical enterprise class storage. zEC12 had **8** core. Westmere EX server had **40** core @2.4GHz. Each system connected via 4 x 8Gb links to DS8800. zEC12 running against 8 SSD DASD CKD volumes. Intel server running against 8 SSD LUNs FB volumes. Note: Storage limitations came into effect at workload counts greater than 96.

Source: IBM CPO

Batch workloads take advantage of zEnterprise capability to support high I/O capacity

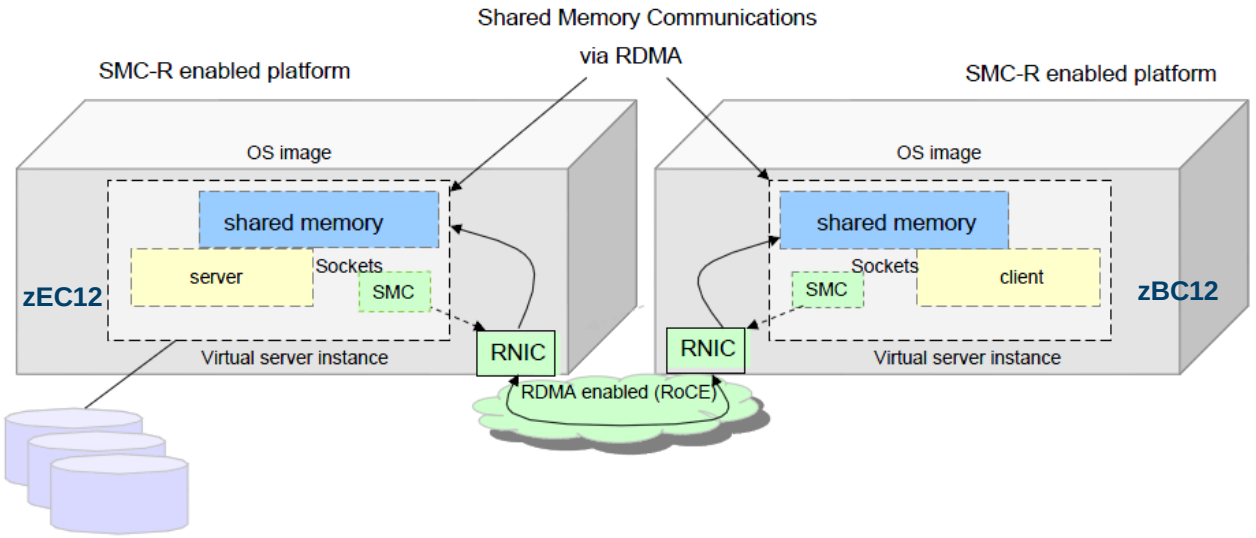
	Intel Xeon E7-4870 + DS8300	z/OS + DS8800
	40 processors 128 GB RAM Linux Sort	8 processors 128 GB RAM DFSORT
		
	Sorting Average CPU 89%	Sorting Average CPU 72%
SORT *Job: Sort a 3 GB transaction file – Repetitions: 300*		
Total Elapsed	2,657 secs	515 secs
Bytes Per Sec	**240 MB**	**3,000 MB**
MERGE *Job: Merge 30 sorted files into a 90 GB master file – Repetitions: 10*		
Total Elapsed	4,051 secs	446 secs
Bytes Per Sec	**157 MB**	**3,460 MB**

13x more I/O bandwidth than Intel

Intel Batch window is 7x longer than z/OS

Source: IBM Internal Study. Intel system was constrained by CPU. Differences in storage device was not a factor in testing. Results may vary based on customer workload profiles/characteristics.

IBM continues to innovate with new PCIe features – Shared Memory Communications (SMC-R) introduced in 2013



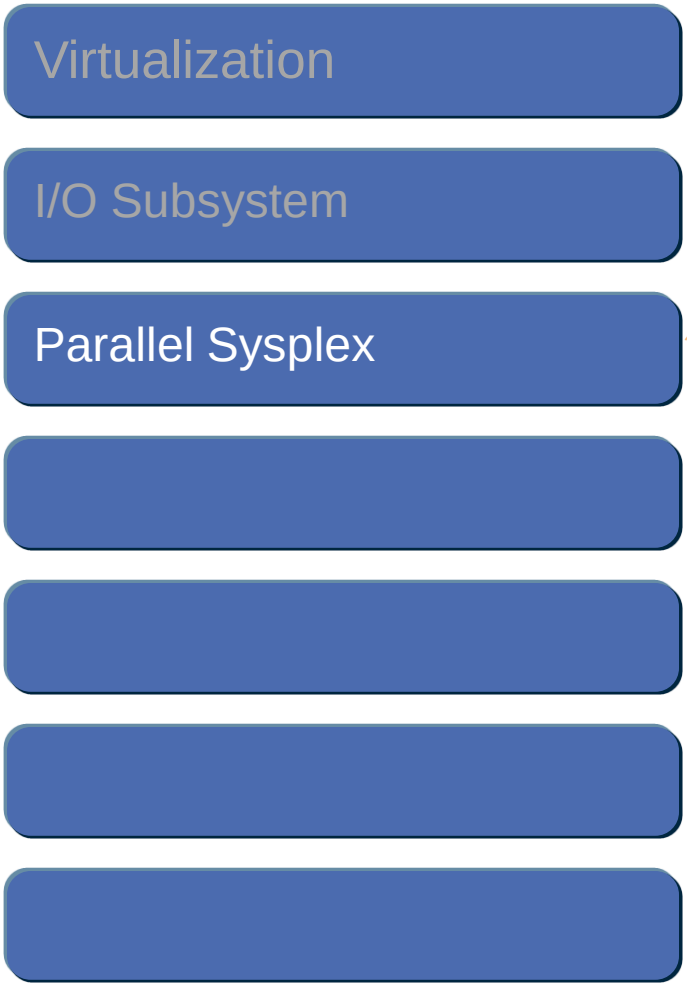
Network latency reduced up to

*80%**

- 10GbE RDMA over Converged Ethernet (RoCE) Express card
- Helps reduce latency and CPU resource consumption
- Runs over TCP/IP across z/OS systems
- Can be used seamlessly by *any* z/OS TCP sockets-based without any changes

* Based on internal IBM benchmarks of modeled z/OS TCP sockets-based workloads with request/response traffic patterns using SMC-R vs. TCP/IP. The actual throughput that any user will experience will vary.

Parallel sysplex gives zEnterprise continuous availability with near linear scalability



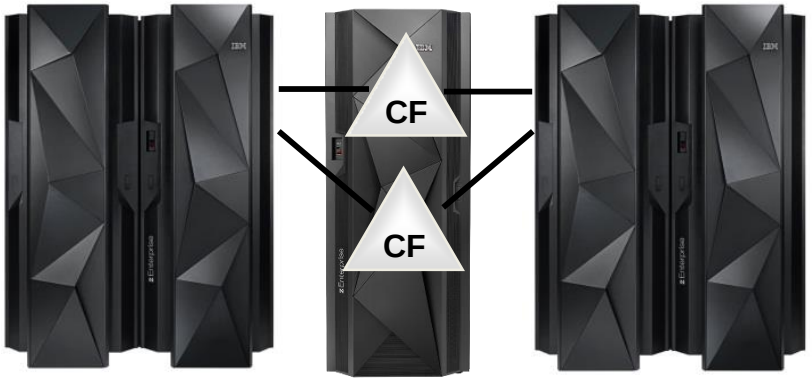
- Optimized to support IBM middleware
- Provides a single image across the cluster
- Centralized design optimizes data sharing
- Enables near-infinite elasticity

zEnterprise parallel sysplex clusters provide unmatched processing power and availability

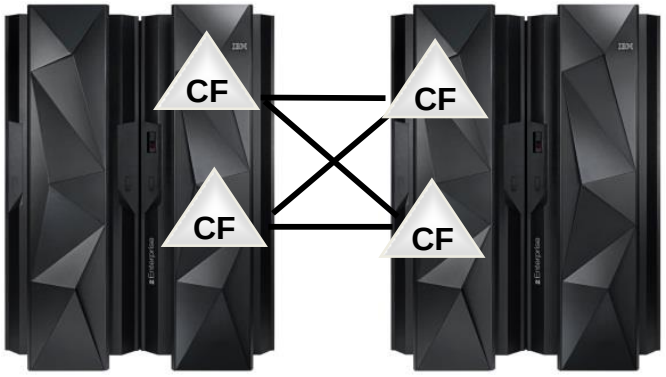
Single System Sysplex

- Clustering driven by specialty engines (Coupling Facility)
- Presents a single system image of a z/OS workload
- Potentially **2.5M MIPS** per 32-way cluster*

*Equivalent to about 240 of the largest Oracle servers



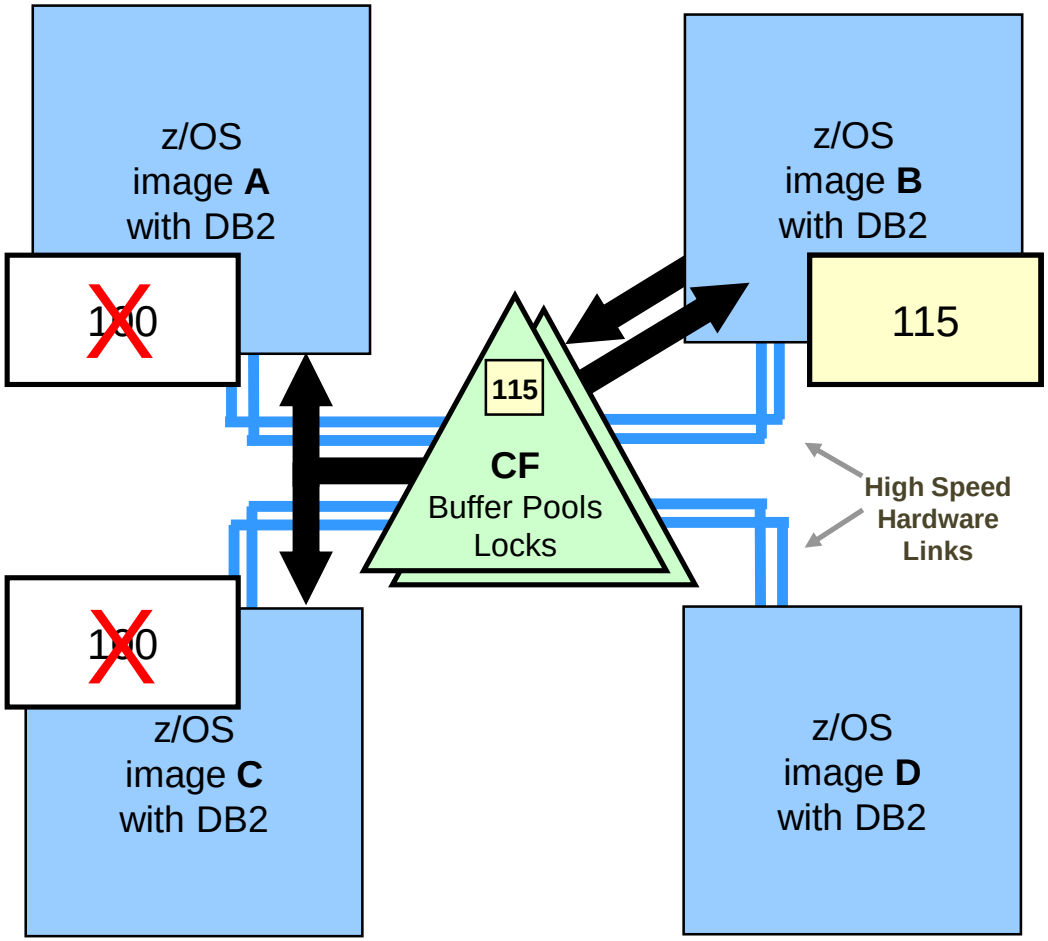
External Coupling Facility
(Can be different class server)



Cross Connected Servers with internal Coupling Facilities

- Enables rolling updates
- Supports continuous access to business services and data – from anywhere, at anytime
- Designed for **99.999%** availability

zEnterprise's centralized Coupling Facility permits efficient lock and cache management in DB2



A and C have data in local buffer pool without locks

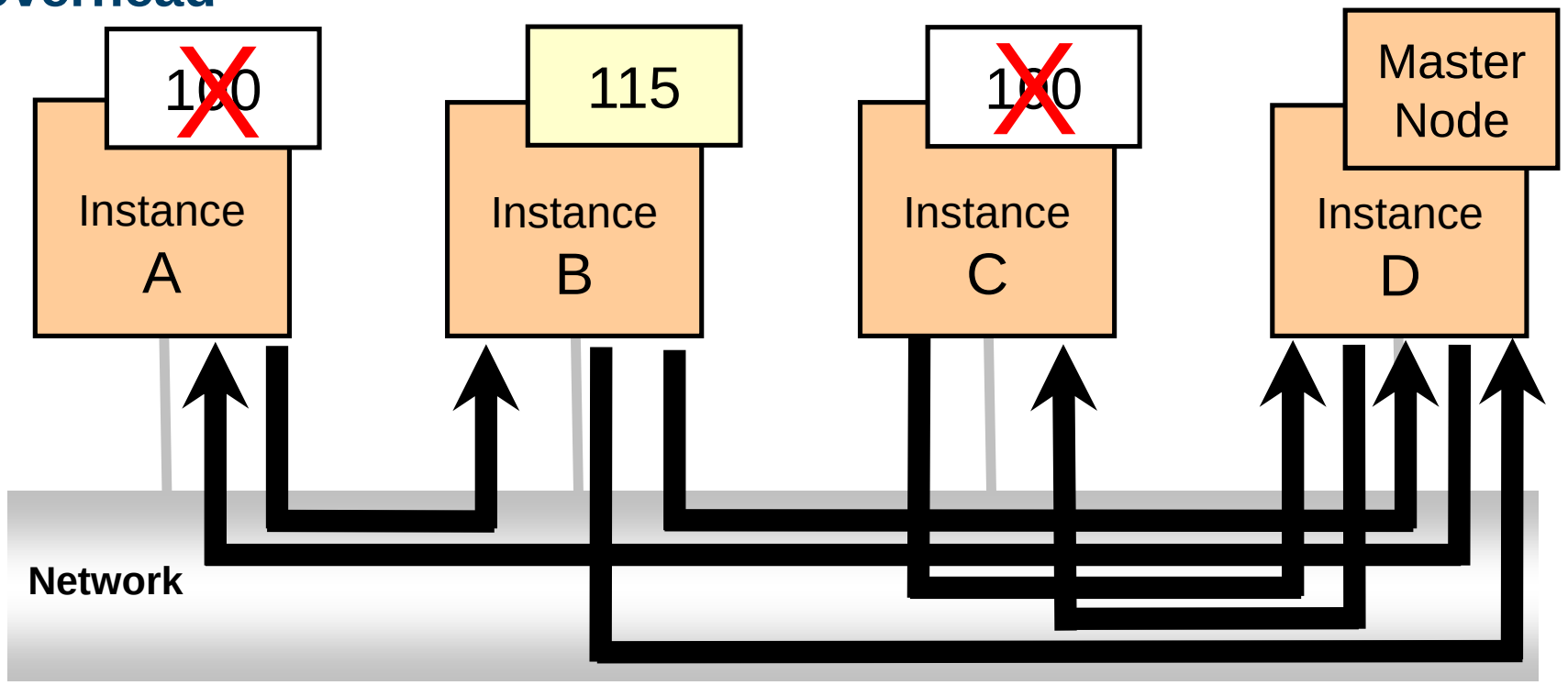
1. B registers page to CF and obtains write lock
2. B updates data
3. B commits update

B caches update in group buffer pool

CF invalidates all cached copies without interrupting processors

Cache and locks are maintained with no inter-node disturbance!

Oracle RAC's distributed lock management design causes overhead



Lock assume

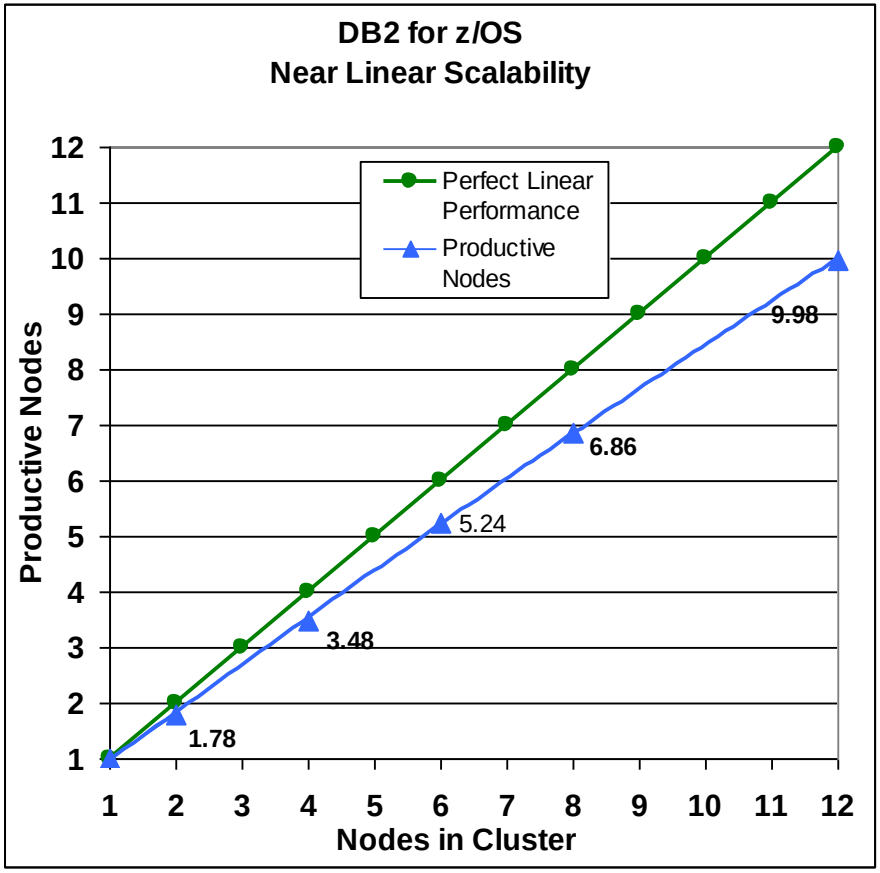
7. B updates local copy

Inter-node connections: **6**

In a cluster with 4 nodes, an update operation may need
6 network connections and two in-memory calls (not shown).

Example based on Oracle's US Patent 7,107,319 B2.

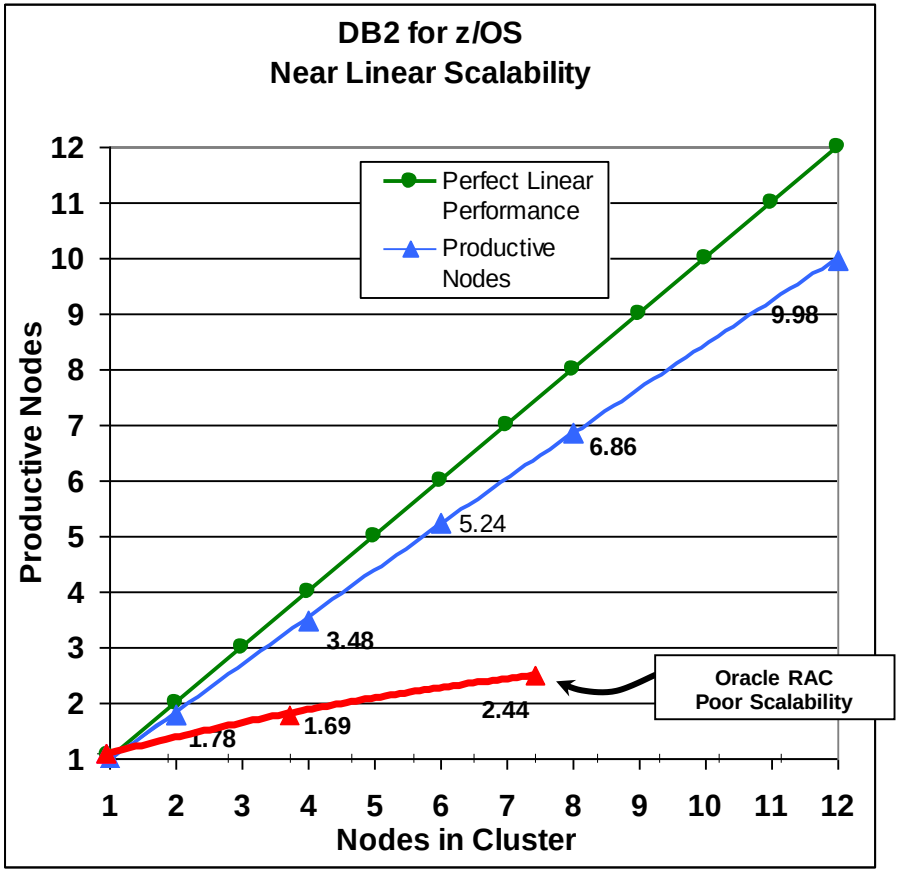
DB2 for z/OS in a parallel sysplex scales efficiently and transparently



- DB2 leverages unique Parallel Sysplex clustering design to achieve near linear scaling
  - No data partitioning required
  - No transaction routing required
  - No cluster awareness required in applications
- Elastic processing capacity
  - Applications are not tied to database partitioning schemes
  - Automatically balances workload across cluster

DB2 for z/OS OLTP result (ITG '03)

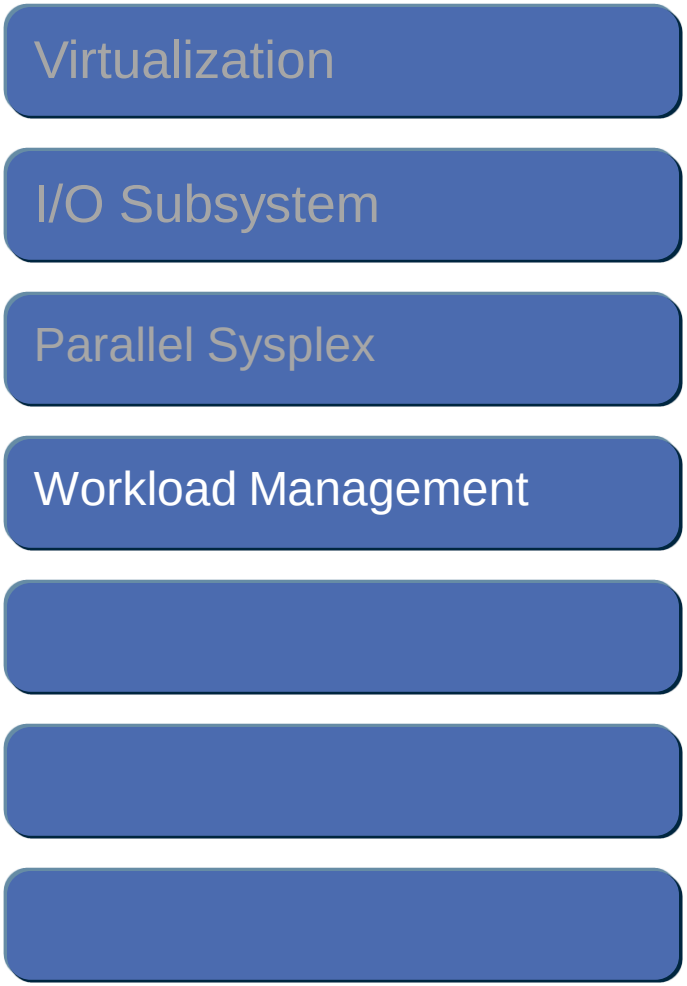
The only option for Intel-based servers is Oracle RAC



- Oracle RAC's lock and cache system is inefficient by design
  - Scaling RAC requires complex tuning and partitioning
  - Application partition awareness makes it difficult to add or remove nodes
- Published studies demonstrate difficult or poor scalability
  - Dell (shown in chart): Poor scalability despite using InfiniBand for RAC interconnect
  - CERN: Four month team effort to tune RAC, change database, change application
  - Insight Technology: Even a simple application on two node RAC requires complex tuning and partitioning to scale

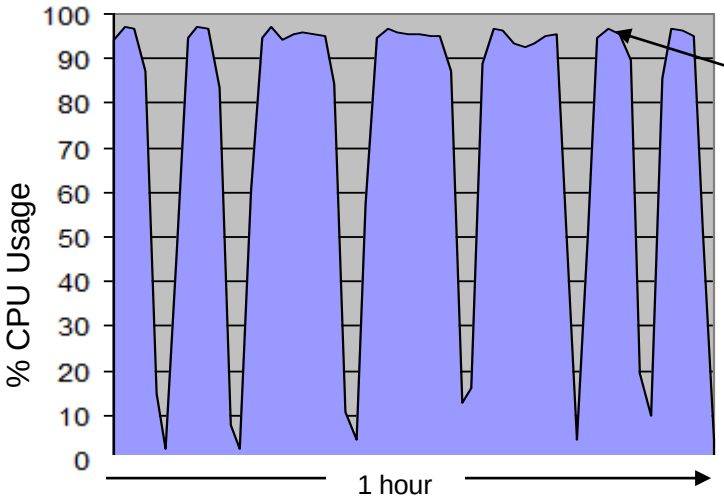
Oracle RAC characteristics as shown in Dell RAC InfiniBand Study http://www.dell.com/downloads/global/power/ps2q07-20070279-Mahmood.pdf
CERN (European Organization for Nuclear Research) http://www.oracleracsig.org/pls/apex/RAC_SIG.download_my_file?p_file=1001900
Insight Technology http://www.insight-tec.com/en/mailmagazine/vol136.html

The zEnterprise demonstrates “perfect” workload management



- Applies across all resources, not just CPU
- Ensures priority workloads meet service level agreements
- Cross platform
- Covers heterogeneous platforms

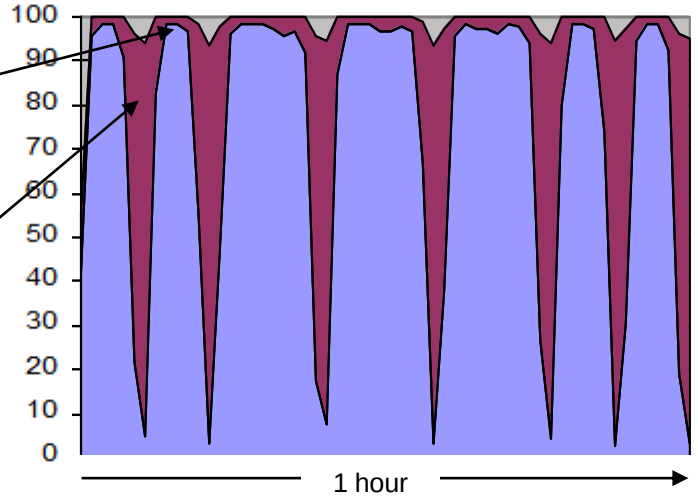
System z demonstrated perfect workload management and very high utilization – x86 hypervisor did neither

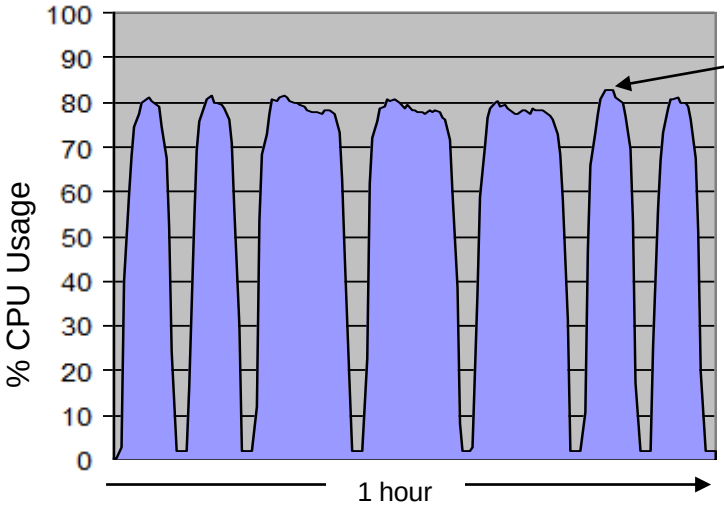


High priority workloads (blue) run at very high utilization and do not degrade

System z

Low priority workloads (maroon) consume all but 2% of remaining resources (gray)

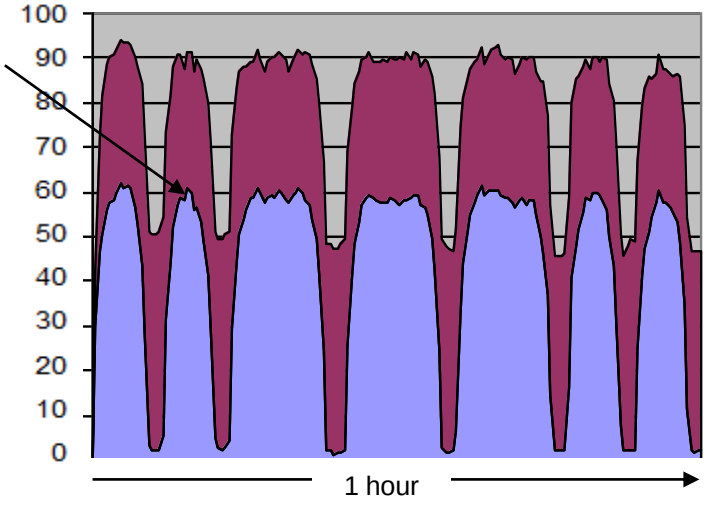




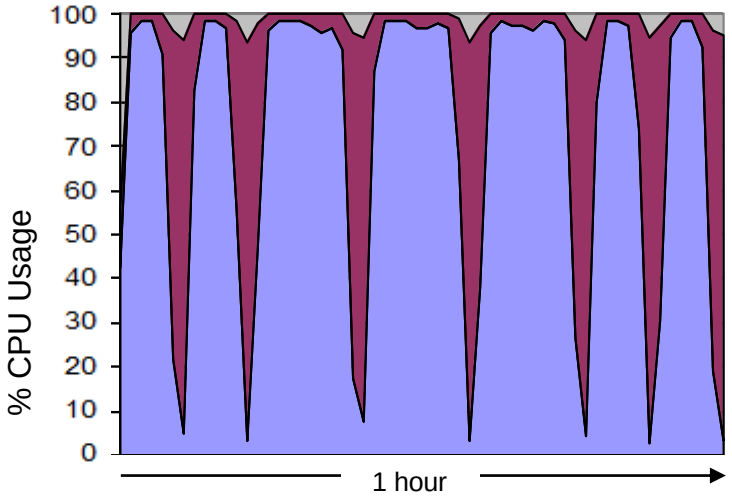
High priority workloads (blue) run at *less* high utilization and *degrade* when low priority workloads (maroon) added

x86 hypervisor

Too much resource (gray) *remains unused* (22%)

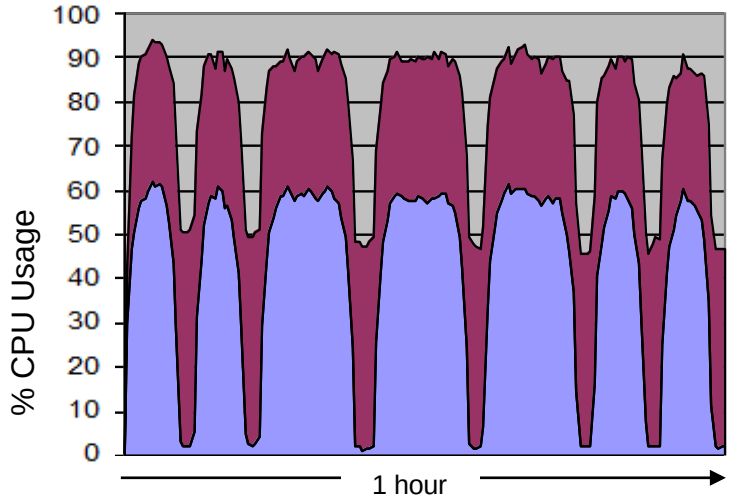


System z virtualization is much more efficient, and assures workload requirements are met



System z

- Perfect workload management
- Consolidate workloads of different priorities on the same platform
- Full use of available processing resource (high utilization)

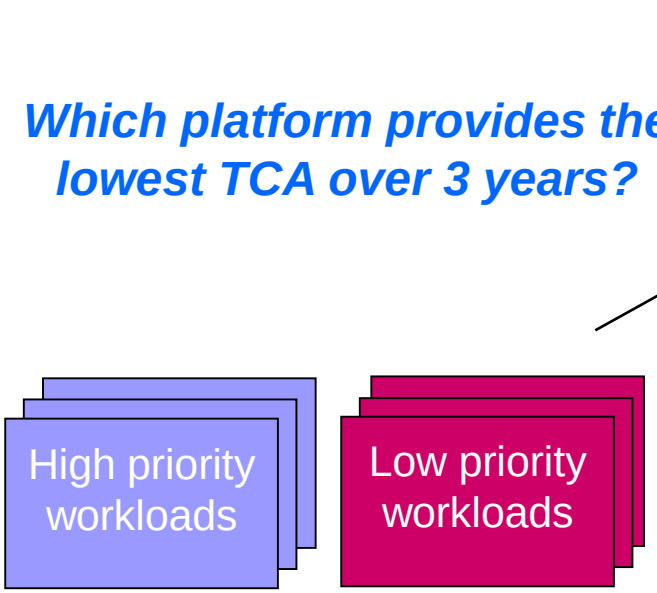


Common hypervisor on Intel

- Imperfect workload management
- *Forces workloads to be segregated on different servers*
- *More servers are required (low utilization)*

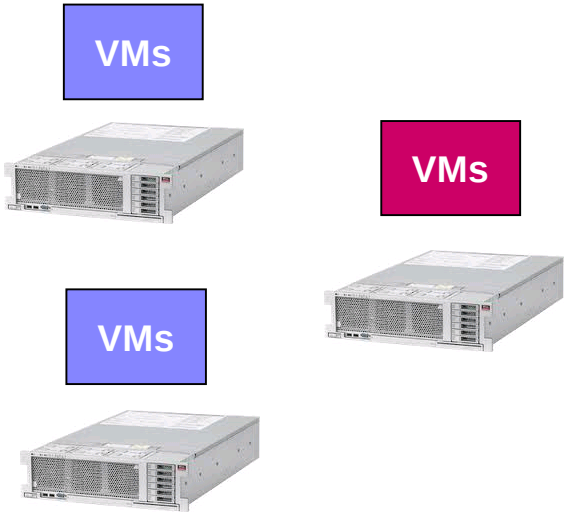
zEnterprise easily manages mixed priority workloads and lowers costs

Which platform provides the lowest TCA over 3 years?



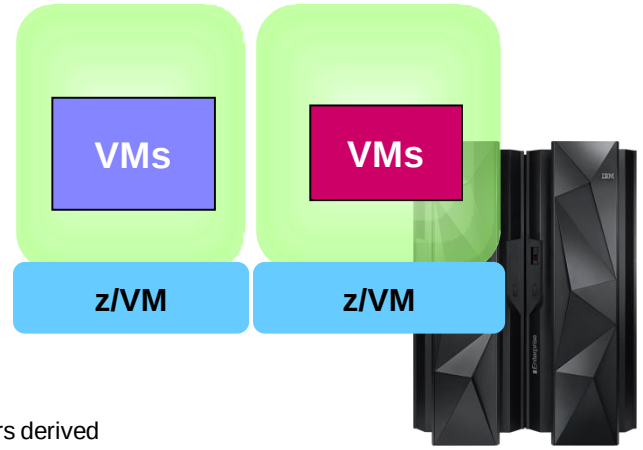
- **IBM WebSphere 8.5 ND**
- **IBM DB2 10 AESE**
- **Monitoring software**

High priority online banking workloads driving a total of **9.1M** transactions per hour and low priority discretionary workloads driving **2.8M** transactions per hour



Virtualized on 3 Intel 40 core servers

$16.3M (3 yr. TCA)



z/VM on zEC12
32 IFLs

$6.6M (3 yr. TCA)

60% *lower cost!*

Consolidation ratios derived from IBM internal studies.. zEC12 numbers derived from measurements on z196. Results may vary based on customer workload profiles/characteristics. Prices will vary by country.

Only zEnterprise offers numerous options for optimizing workloads to reduce costs

- Virtualization
- I/O Subsystem
- Parallel Sysplex
- Workload Management
- Workload Optimization
-
-

- Tuned for highly efficient transaction handling
- Specialty engines for offload of some specific workloads
- Appliances can be added for workload acceleration
- Reduces costs and improves price/performance ratio

System z is first server to implement Hardware Transactional Memory

- Software-defined sequence treated by hardware as atomic "transaction"
- Enables significantly more efficient software
  - Highly-parallelized applications
  - Better concurrency for multi-threaded applications
  - Speculative code generation
- Exploited by Java and shortly z/OS. HLASM and C/C++ compiler syntax available. Longer-term opportunities for DB2, z/VM and others

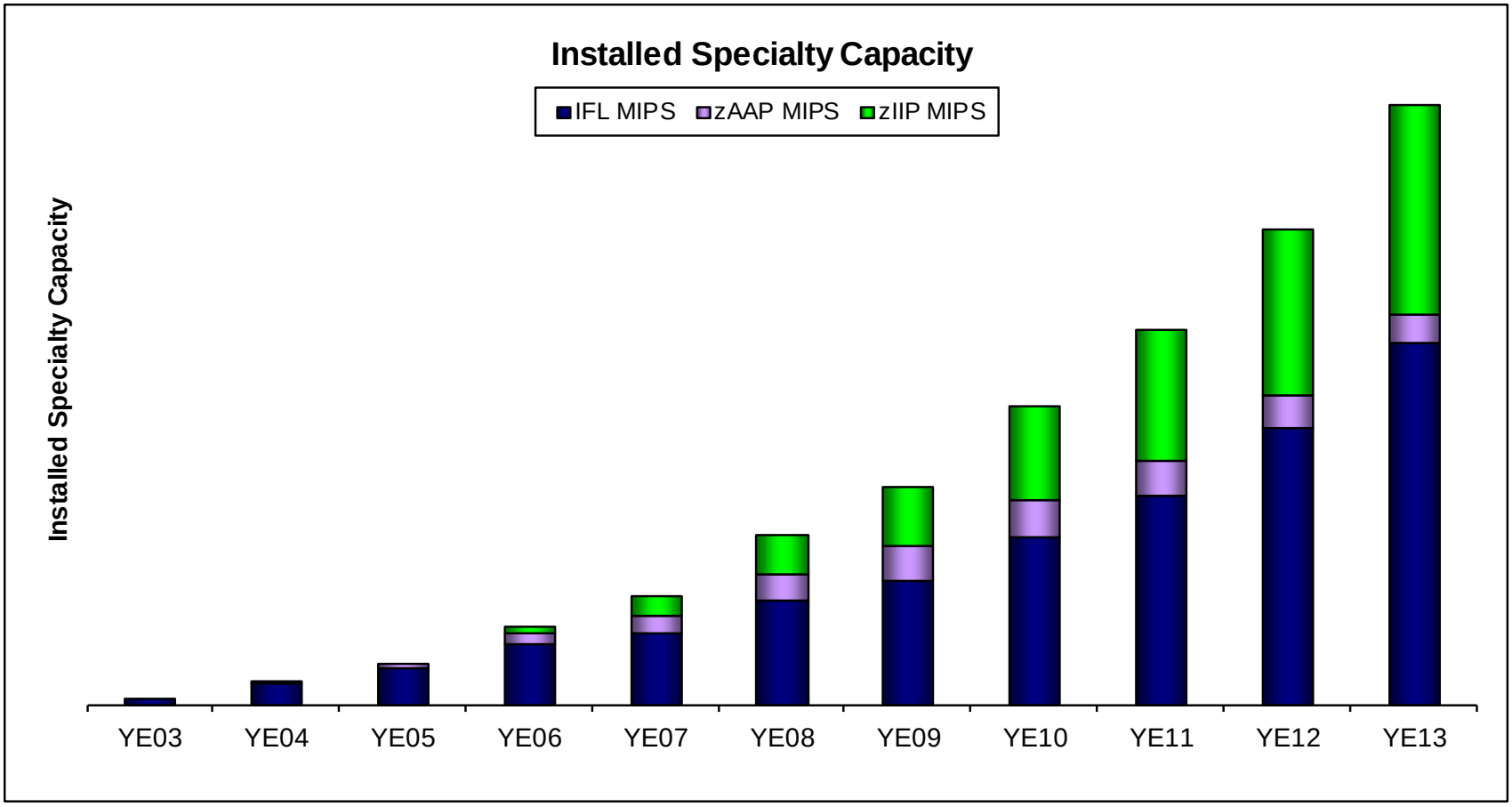
One of a number of features contributing to aggregate 60% improvement in throughput for Java workloads

```
* R1  - address of the new queue element to be inserted.
* R2  - address of the insertion point; new element is inserted
        before the element pointed to by R2.

NEW             USING       QEL,R1
CURR            USING       QEL,R2
                SETLOCK     OBTAIN, …     Serialize access to queue.


                LG          R3,CURR.BWD       Point to previous element.
PREV            USING       QEL,R3            Make it addressable.
                STG         R1,PREV.FWD       Update prev. forward ptr.
                STG         R1,CURR.BWD       Update curr. backward ptr.
                STG         R2,NEW.FWD        Update new forward ptr.
                STG         R3,NEW.BWD        Update new backward ptr.
                SETLOCK     RELEASE, …
```

```
* R1  - address of the new queue element to be inserted.
* R2  - address of the insertion point; new element is inserted
        before the element pointed to by R2.

NEW             USING       QEL,R1
CURR            USING       QEL,R2
                LHI         R15,10          Load retry count.
LOOP            TBEGIN      TDB,X'C000'     Begin transaction (save GRs 0-3)
                JNZ         ABORTED         Nonzero CC means aborted.
                LG          R3,CURR.BWD     Point to previous element.
PREV            USING       QEL,R3          Make it addressable.
                STG         R1,PREV.FWD     Update prev. forward ptr.
                STG         R1,CURR.BWD     Update curr. backward ptr.
                STG         R2,NEW.FWD      Update new forward ptr.
                STG         R3,NEW.BWD      Update new backward ptr.
                TEND        TDB             End transaction.
                ...
ABORTED         JO          NO_RETRY        CC3: Nonretryable abort.
                JCT         R15,LOOP        Retry transaction a few times.
                J           NO_RETRY        No joy after 10x; do it the hard way.
```

Source: IBM. Multi-threaded benchmark run on z/OS 1.13 comparing z196 with Java7SR1 and zEC12 with Java 7SR3

System z installed specialty engine capacity



Workload optimizations are achieved via special I/O cards

zEnterprise Data Compression (zEDC) introduced in 2013

- Compatible with current coprocessor-based compression
- Specifically designed for large amounts of bulk data
- Cost effective – reduces CPU overhead, and storage overhead
- Optimizes cross-platform exchanges
  - Compatible with zlib compression – an industry standard widely used across all platforms

Up to **4x** data compression

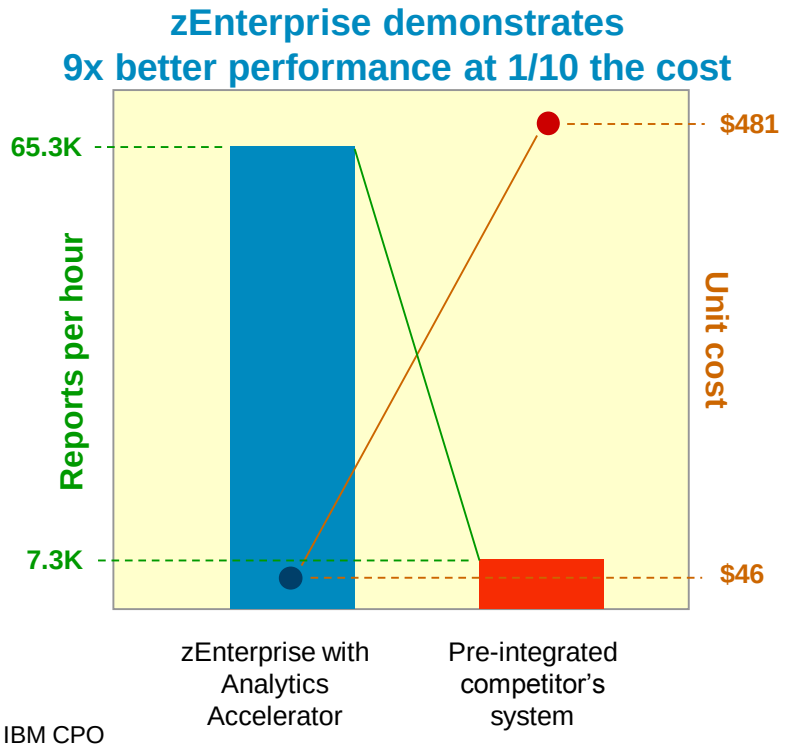
Up to **118x** reduction in CPU

Up to **24x** throughput improvement with zlib

Source: IBM

IBM DB2 Analytics Accelerator speeds up deep analytics queries

- A workload-optimized, blade-based appliance that runs queries in seconds versus hours
- Integrated with DB2 for z/OS, and transparent to applications
- Drives down the costs of data warehousing and business analytics

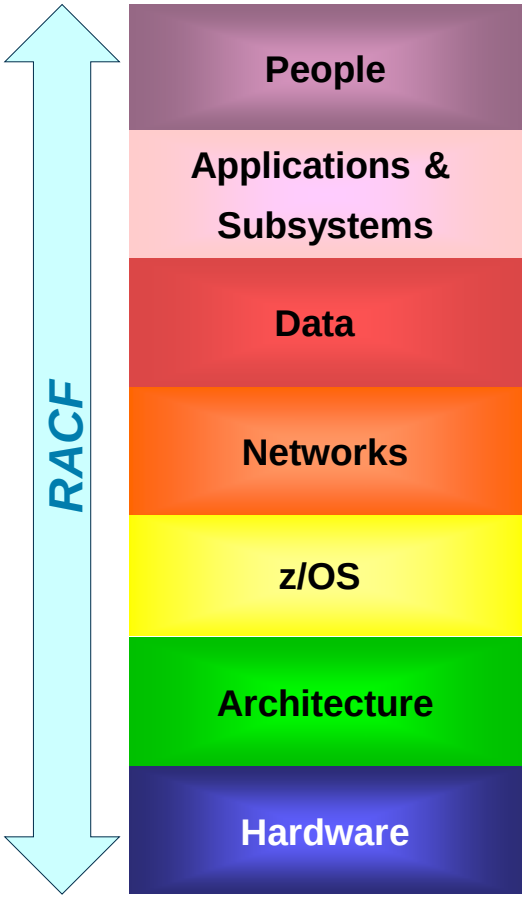


Source: IBM CPO

zEnterprise – the *most* secure commercially available platform

- Highest commercially available EAL ratings
- Multiple encryption options
- Provides full function Public Key certificate authority
- APIs extend encryption services across the enterprise
- State of the art security monitoring

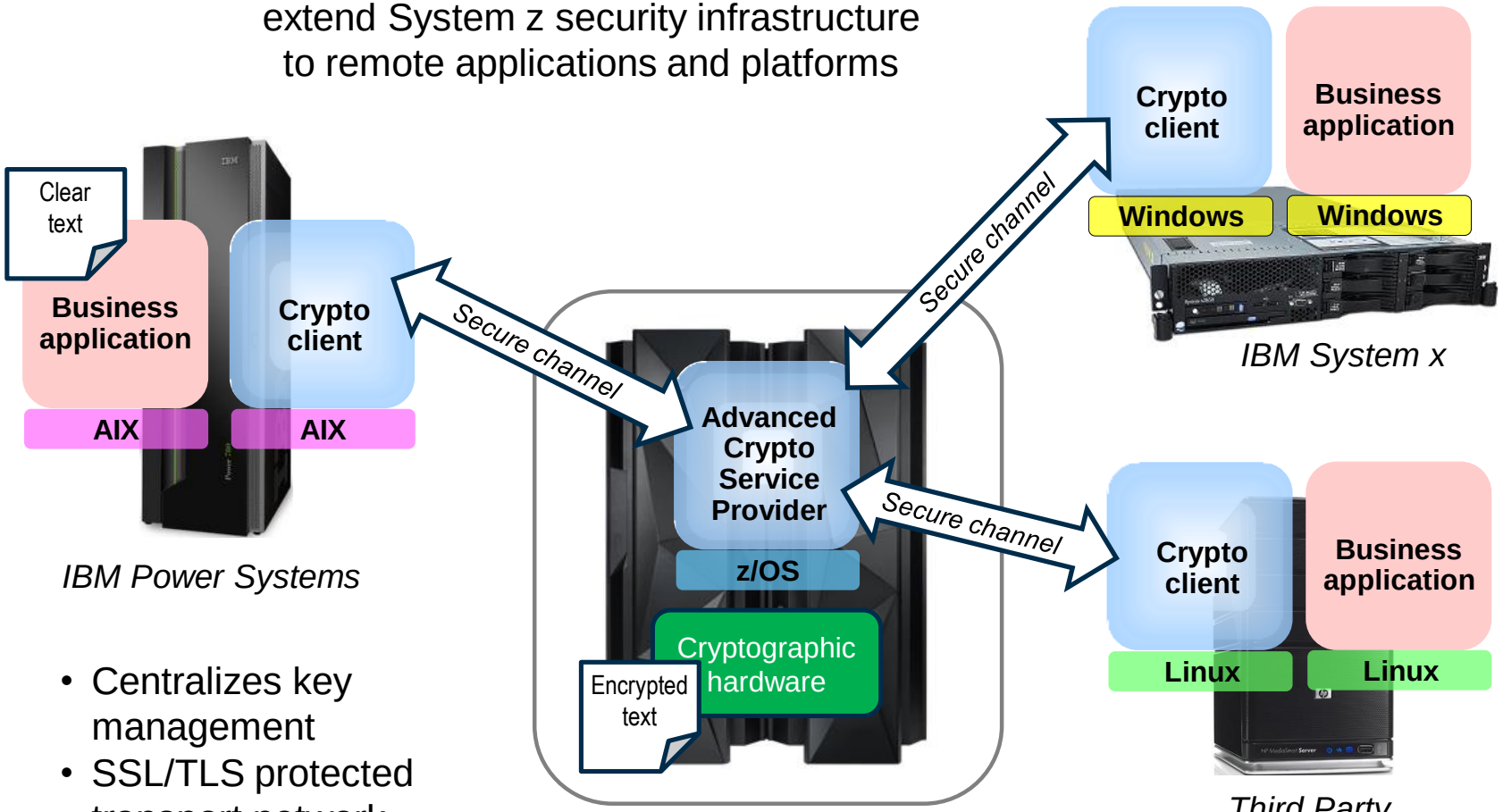
Resource Access Control Facility (RACF) provides security throughout the entire zEnterprise stack



- Tools, reporting, auditing
- Access control to all classes of resources
- Integrated into the operating system
- Provides Enterprise Identity Management
- Supports cryptographic services
- Supports digital certificates

System z is the *hub* of security for the data center

IBM's Advanced Cryptographic Services extend System z security infrastructure to remote applications and platforms



- Centralizes key management
- SSL/TLS protected transport network

Virtualized System z security is superior to other platforms and augmentation costs less

Security Natively Covered by Platform

Security Level Description	IBM System z	x86	Competitive UNIX
Normal corporate	100.00%	18.16%	30.26%
Credit card processing involved	99.00%	11.04%	18.28%
Banking	94.00%	5.26%	10.22%
Healthcare	100.00%	3.24%	8.51%
Research	92.50%	2.86%	4.16%
Defense	85.54%	0.26%	1.86%

- On System z, most security requirements are standard
- Major security deficiencies exist on distributed platforms

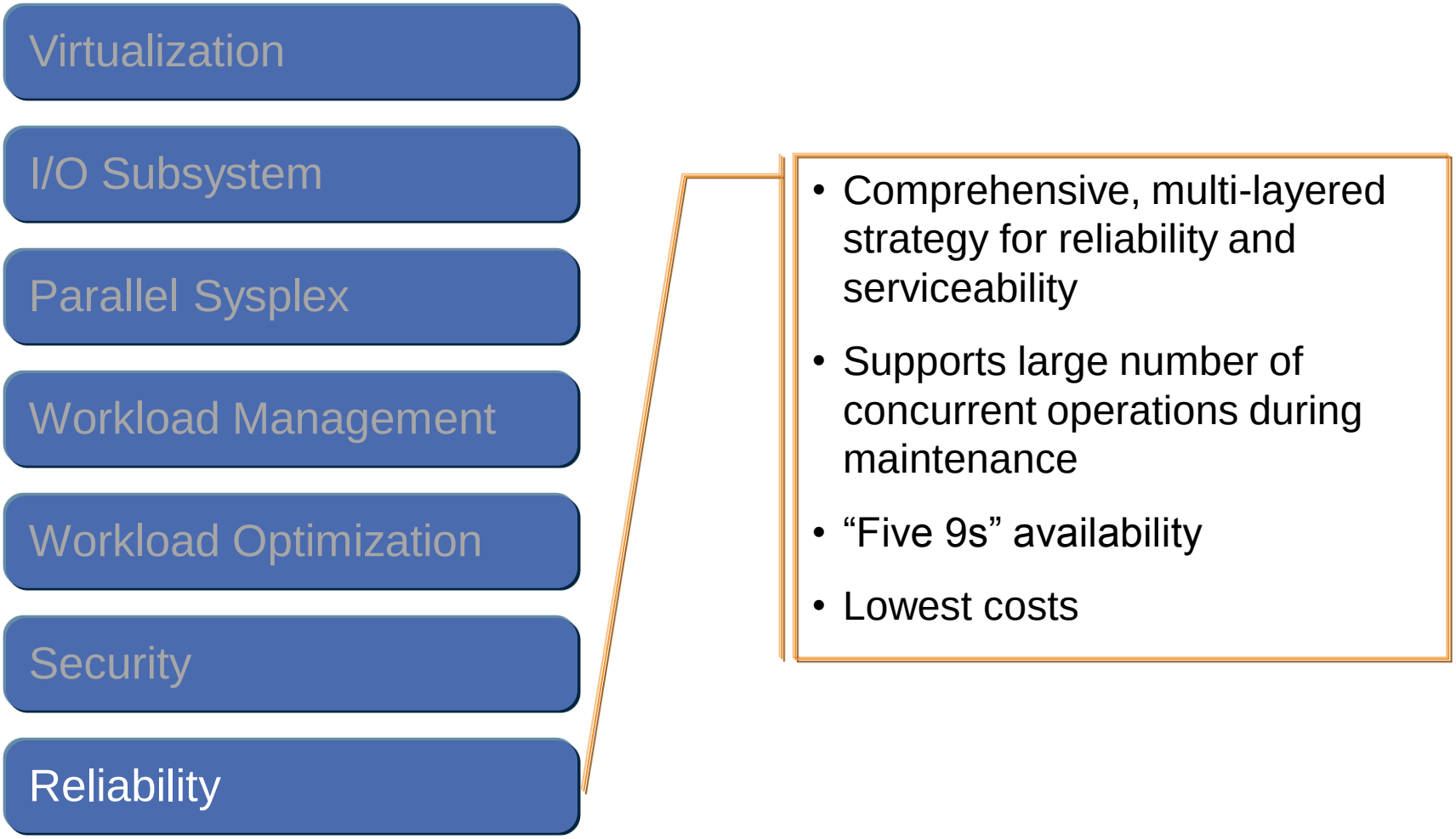
- Distributed platforms require considerable additional expense to achieve required security levels

Incremental Cost to Achieve Required Security

Security Level Description	IBM System z	x86	Competitive UNIX
Normal corporate	0.00%	32.54%	12.37%
Credit card processing involved	2.32%	46.27%	29.53%
Banking	2.07%	51.31%	26.58%
Healthcare	0.00%	67.26%	35.89%
Research	4.28%	91.26%	64.28%
Defense	11.36%	125.41%	102.26%

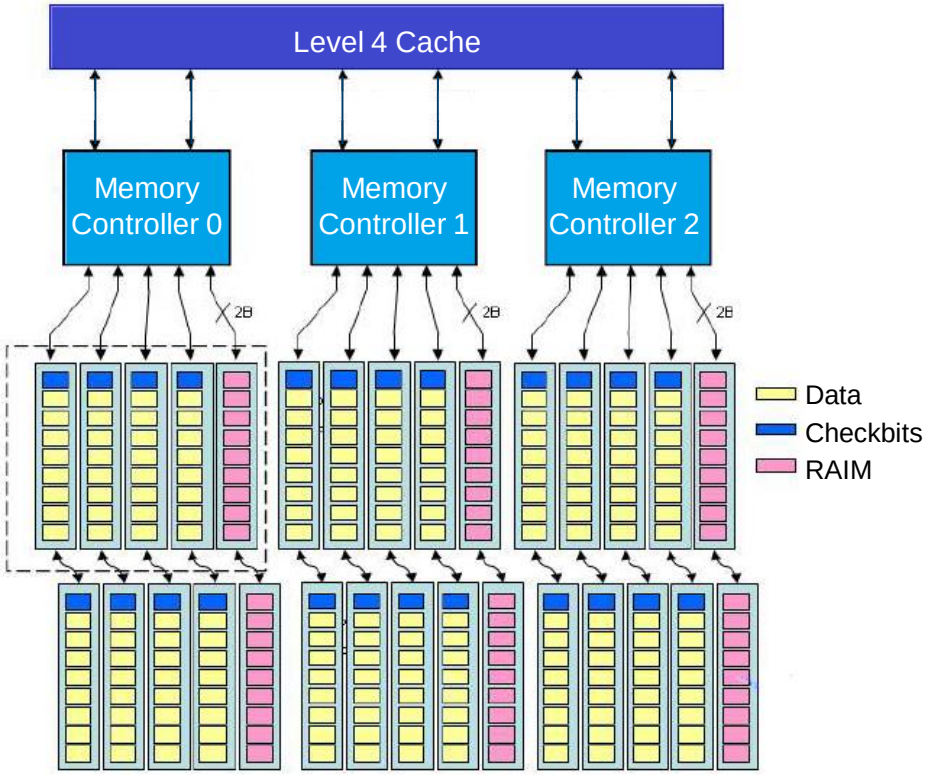
Source: "Tracked, Hacked and Attacked?"

zEnterprise's reliability, availability and serviceability are legendary



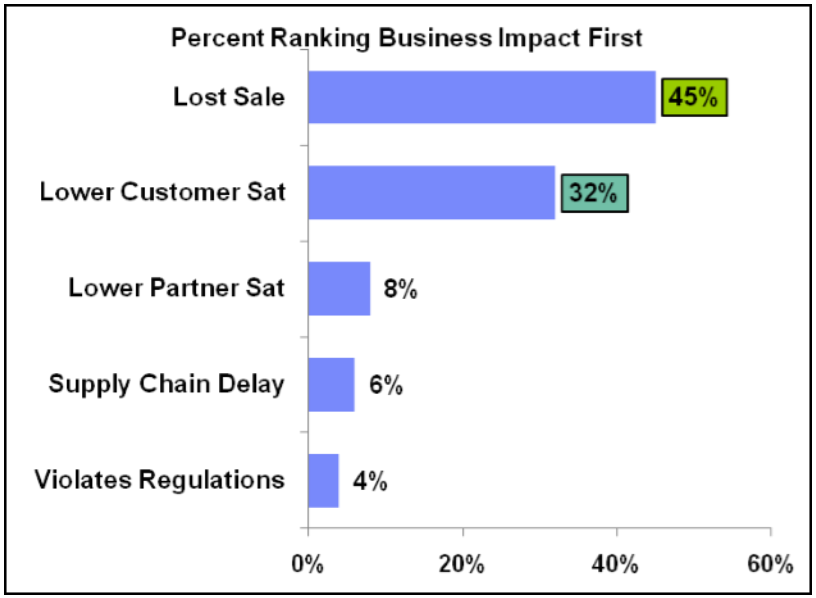
Redundant Array of Independent Memory (RAIM) provides more protection against failures, improving availability

- Soft memory errors are primarily caused by background radiation (i.e., cosmic rays)
- Most servers use ECC (error correcting code) and parity checking to correct these errors
- System z uses RAIM – more robust than ECC
  - Each Memory Controller has an extra channel, equivalent to 20% additional memory
  - Protects against DRAM, socket, memory channel or DIMM failures
  - More cost effective than full 100% memory mirroring (i.e., complete redundancy)
  - No performance penalty



Downtime seriously effects sales, revenue, customer satisfaction

Business Impact of 10 Minutes of Downtime



Source: IBM Customer Survey

Revenue Impact of Downtime per Hour

Figure 1 Cost of downtime by industry segment

Average = $2.7M

Industry/Sector	Revenue/Hour
Energy	$1,468,798
Telecommunications	$4,611,604
Financial	$8,213,470
Information Technology	$3,316,058
Insurance	$2,582,382
Pharmaceuticals	$2,058,710
Banking	$1,145,129
Consumer Products	$989,795
Chemicals	$1,071,404
Transportation	$1,463,128

Source: Robert Frances Group 2006

Profit Impact of Downtime

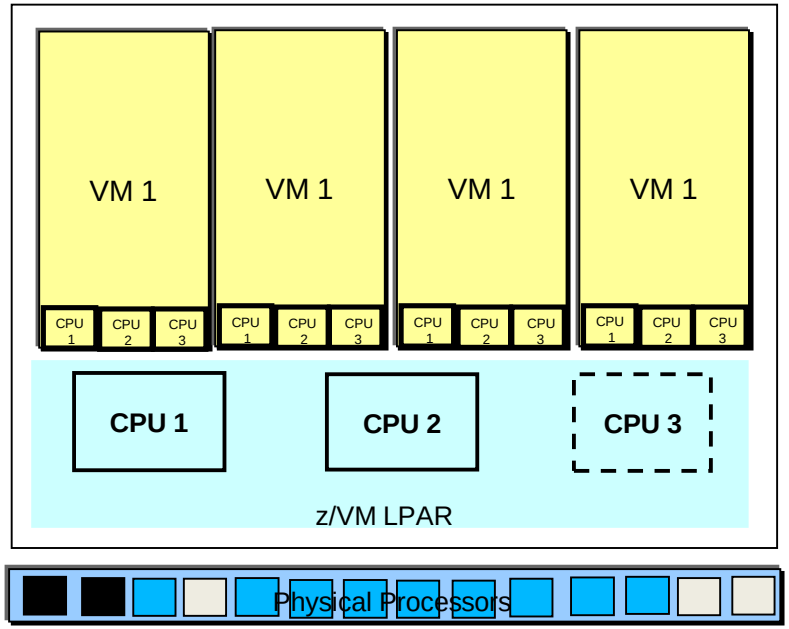
A Telco	%	Profit 2009	Profit/Hr	Profit/Min
Wireless	68%	$3,000,000,000	$342,466	$5,708
Cable	29%	$1,300,000,000	$148,402	$2,473
Media	3%	$120,000,000	$13,699	$228
Total	**100%**	**$4,420,000,000**	**$504,566**	**$8,409**

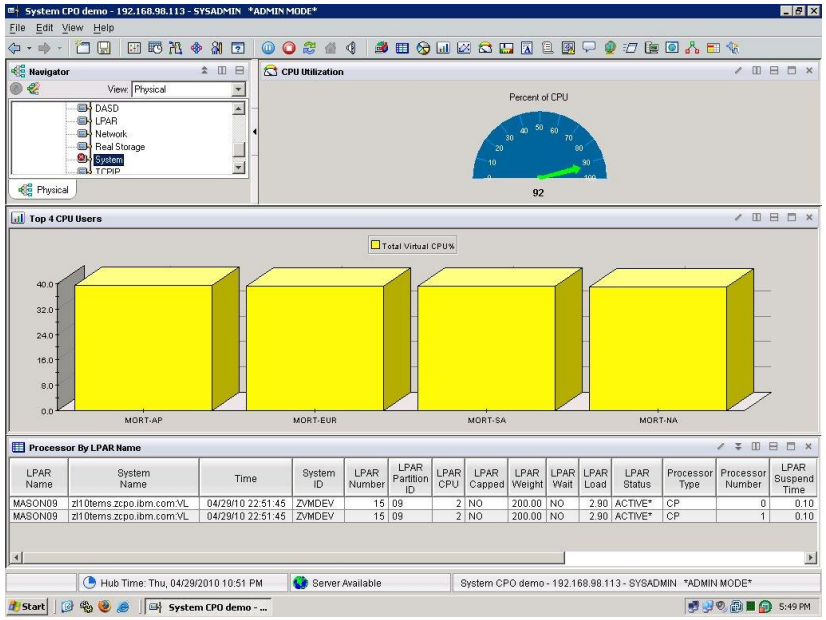
zEnterprise supports concurrent operations during maintenance

Capability	zEC12	x86
ECC on Memory Control Circuitry	Transparent While Running	Can recognize/repair soft errors while running; limited ability with hard errors
Oscillator Failure	Transparent While Running	Must bring server down to replace
Core Sparing	Transparent While Running	Must bring server down to replace
Microcode Driver Updates	While Running	Some OS-level drivers can update while running, not firmware drivers; reboot often required
Book Additions, Replacement	While Running	Must bring server down
Memory Replacement	While Running	Must bring server down
Memory Bus Adaptor Replacement	While Running	Must bring server down
I/O Upgrades	While Running	Must bring server down to replace (limited ability to replace I/O in some servers)
Concurrent Driver Maintenance	While Running	Limited – some drivers replaceable while running
Redundant Service Element	2 per System	“Support processors” can act as poor man’s SE, but no redundancy

Single book systems may not support concurrent memory upgrades

DEMO: Dynamically add processing capacity to z/VM LPAR to handle increased workload… *without disruption*





Tivoli Enterprise Portal

- Guest VMs run without disruption
- Dynamically add logical processors to z/VM LPAR
- Dynamically add processors shared among LPARs

Today's mainframe – 50 years of *continuous* innovation…

- Virtualization
- I/O Subsystem
- Parallel Sysplex
- Workload Management
- Workload Optimization
- Security
- Reliability

IBM zEnterprise EC12

Now let's look at several new opportunities for zEnterprise workloads…