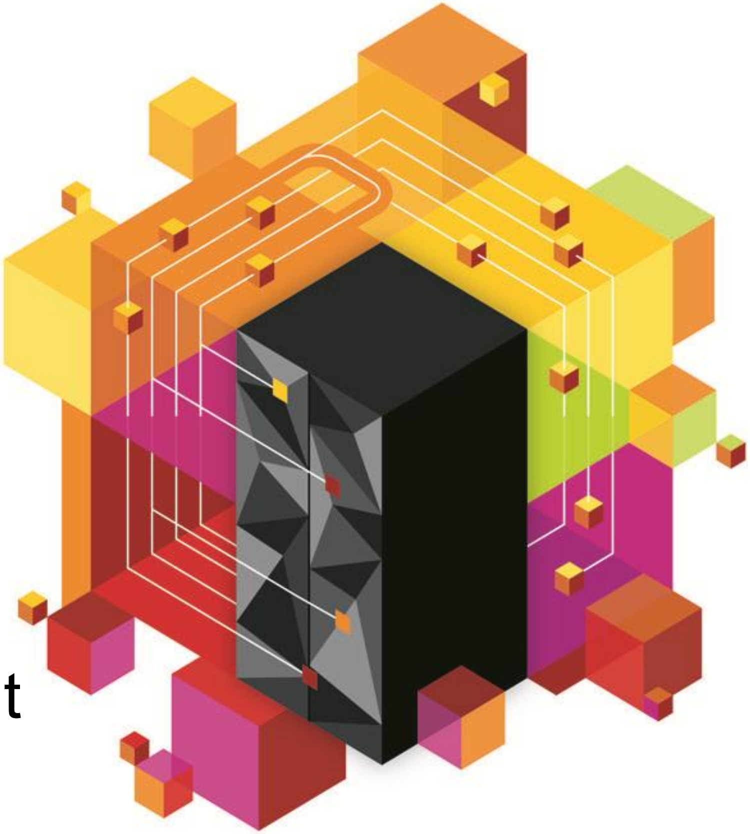
IBM zEnterprise Technology Summit



The New zEnterprise –
A Cost-Busting Platform

What System z Can Do That Intel Can't

System z Delivers More Raw Processing Capacity Than Intel

*World's **fastest** clock speed*	**5.5 GHz**
Total cores	**120**
Configurable cores	**101**
General processor core performance	**1,514 MIPS**
Specialty processor core performance	**1,514 MIPS**
Total Capacity	**78,426 MIPS**

zEC12

Maximum x86 clock speed = **3.4 GHz**

Maximum x86 cores = **32**

Intel Sandy Bridge

What System z Can Do That Intel Can't

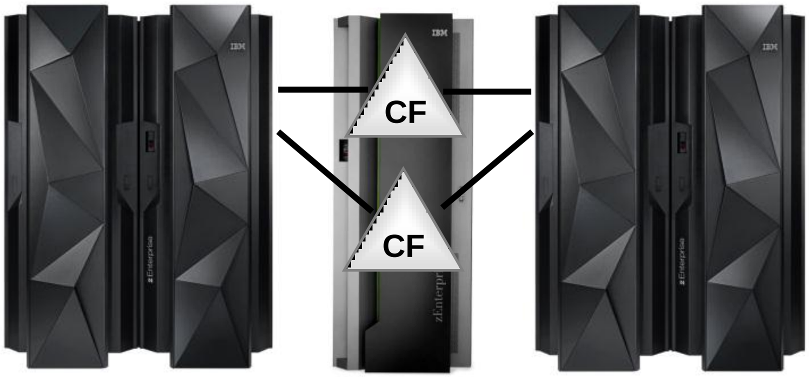
1. Run Bigger and More Workloads

Intel Sandy Bridge

System z

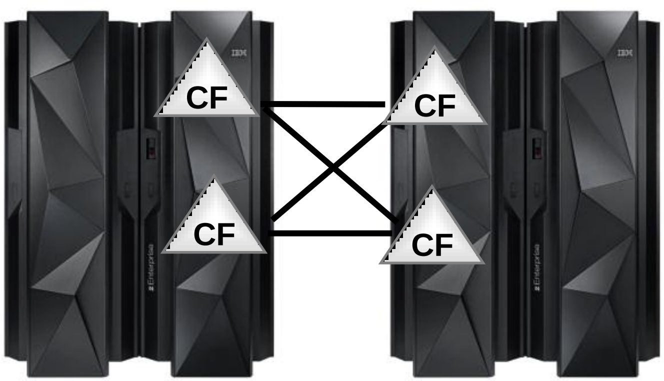
Parallel Sysplex Enables System z To Scale To Capacities Far Beyond What Intel Can

Parallel sysplex clustering delivers **highest availability**



External Coupling Facility
(Can be different class server)

Single System Sysplex



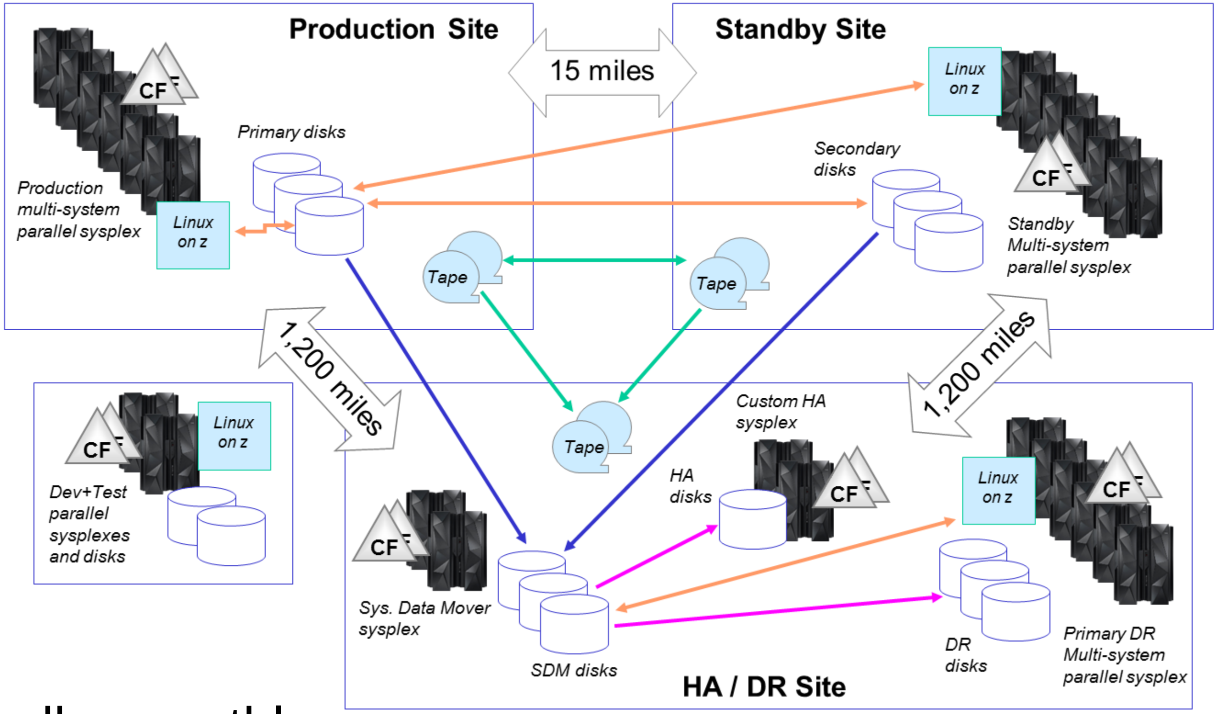
Cross Connected Servers with internal Coupling Facilities

Potentially 2.5 million MIPS per 32-way cluster

Supports rolling software updates via automatic sysplex failover

Intel Does Not Have The Physical Capacity For State-of-the-Art Systems Of This Magnitude

- 1B CICS trans/day
- 4,000 IMS trans/sec
- 14M ACH transactions in 2.5 hours
  - 6-way sysplex
  - 30ms response
  - 216 CPUs at primary site
  - 200K MIPS

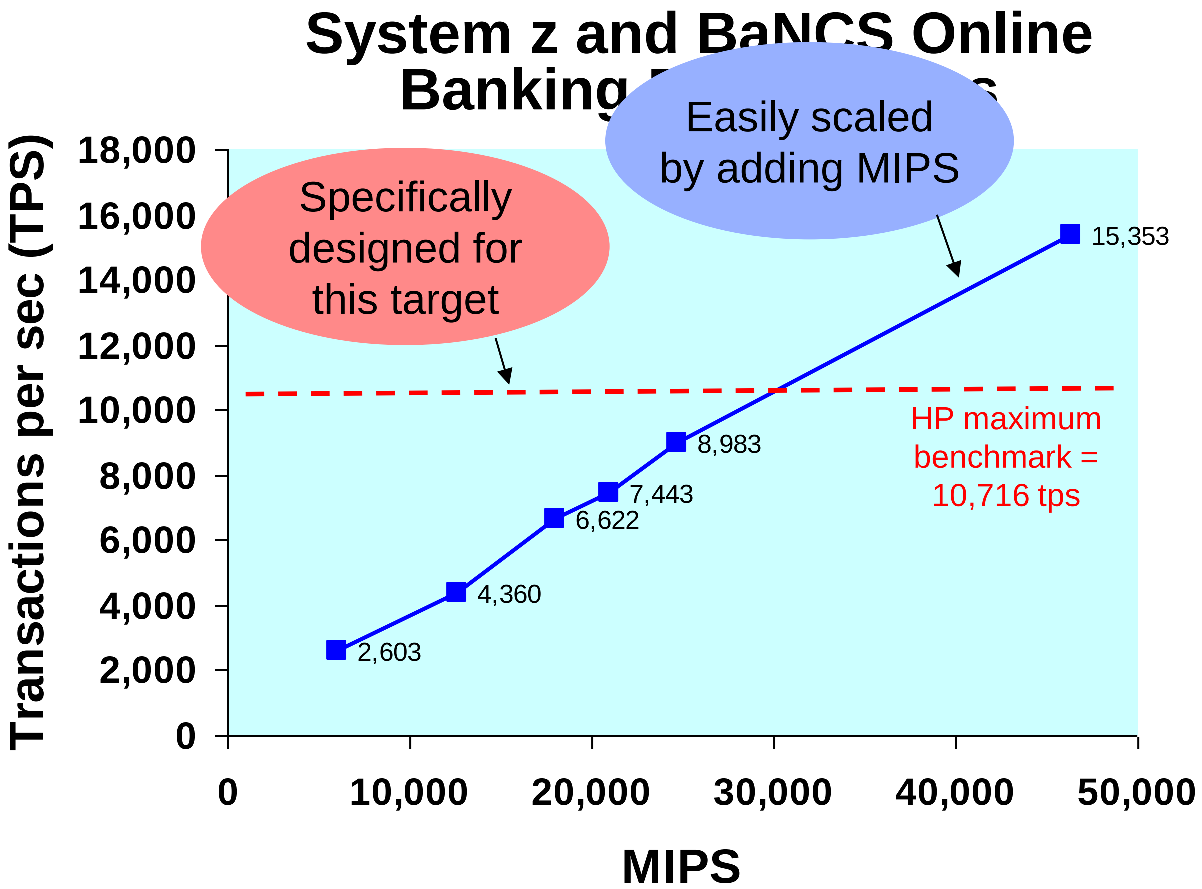


- Flip production and standby monthly
- Zero outages, zero customer impact
- Linux is Active-Active in the two data centers, with zero downtime
  - 15% Linux, growing at 30%
- *"Crazy about security overall, and the z system has a fortress around it"*

Real-World Benchmarks Show System z Runs Bigger Workloads Than Intel

- **Kookmin Bank**
  - **IBM System z and DB2**
  - TCS BaNCS
  - **15,353** Transactions/second
  - **50** Million Accounts
  - IBM benchmark for customer
  - DB2 V9, CICS 3.1, z/OS V1.8

- **State Bank of India**[1]
  - **HP Superdome**
  - **TCS BaNCS**
  - **10,716** Transactions/second
  - **500** Million Accounts
  - Largest banking benchmark performance claimed by HP



[1] Source: http://www.tcs.com/SiteCollectionDocuments/Case%20Studies/BaNCS_Case-Study_SBI-Celent_120210.pdf

System z Has More Cache Than Intel To Support Cache Intensive Workloads

zEC12 chip

6 cores per chip

L1 Cache 960KB

L2 Cache 12MB

L3 Cache 48MB
(**8MB per core**)

L4 Cache 1,536MB across 4 books

Memory 3TB

Sandy Bridge chip

8 cores per chip

L1 Cache 512KB

L2 Cache 2MB

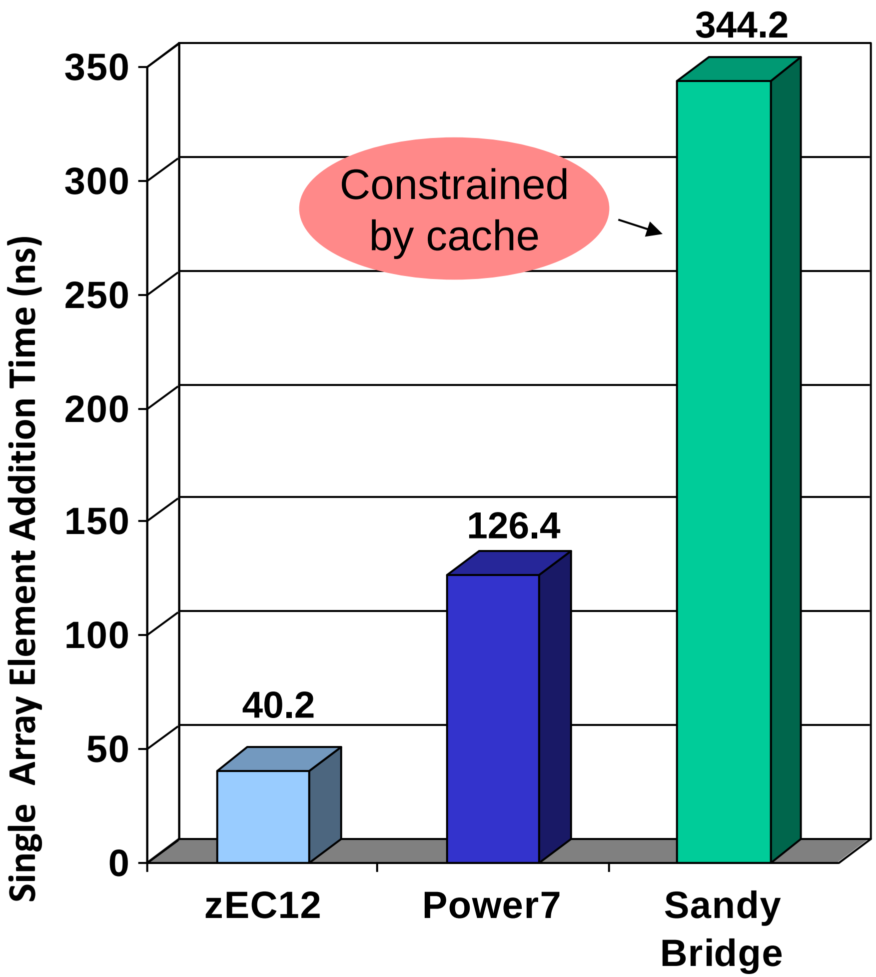
L3 Cache 20MB
(**2.5MB per core**)

No L4 Cache
Processor reported busy during a memory fetch, but no useful work is getting done

Memory 768GB

Intel Servers Slow Down Under Cache Intensive Workloads

- Multiple concurrent processes introduces cache contention
  - Example: 5 processes each with 70MB working set size
- Intel workloads significantly slowed due to cache contention
- System z with z/OS showed results 8X faster than Intel system



System z Is More Efficient For Data Processing Workloads

Cost advantage for smaller scale SAP database

SQL Server on Intel

SAP Applications

Database

4 x HP DL980 2.13GHz 4ch/32co

128 DB cores

DB2 on z/OS

SAP Applications

Database

zEC12 with 3 GP + 2 zIIPs

5 cores

***26X** less cores*
***29%** less cost*

Database Unit Cost
$86/User

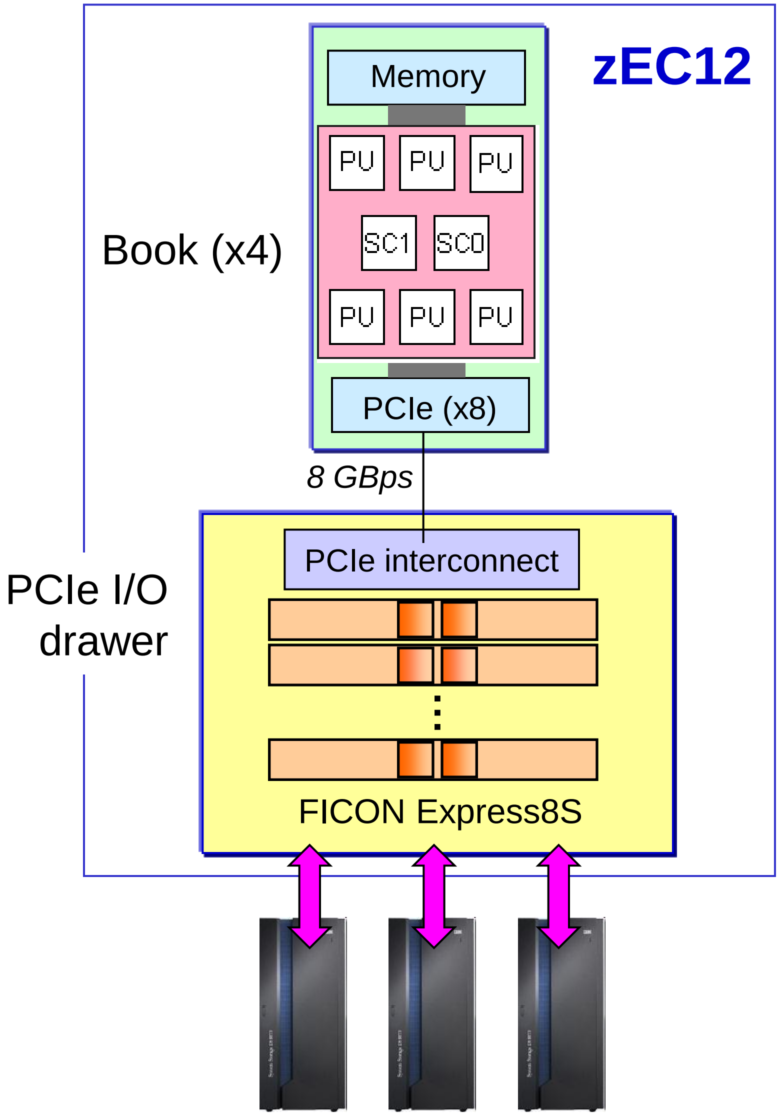
# of Users	23,000
Hardware	$0.34M
Software	$1.64M
Total (3 yr. TCA)	$1.98M

Database Unit Cost
$61/User

# of Users	23,000
DB2 Solution Edition(HW+SW)	$1.40M
Total (3 yr. TCA)	$1.40M

Note: Workload Equivalence established from a large US Retailer SAP DB offload incorporating estimated CPU Savings from DB2 for z/OS upgrade (107 Performance Units per MIPS). Upgrading from DB2 V8 to V10 reduces average CPU usage by 28%. DB2 V10 for z/OS on zEC12 and SQL Server 2008 on Intel

System z Has A Dedicated I/O Subsystem For High I/O Bandwidth, Intel Doesn't

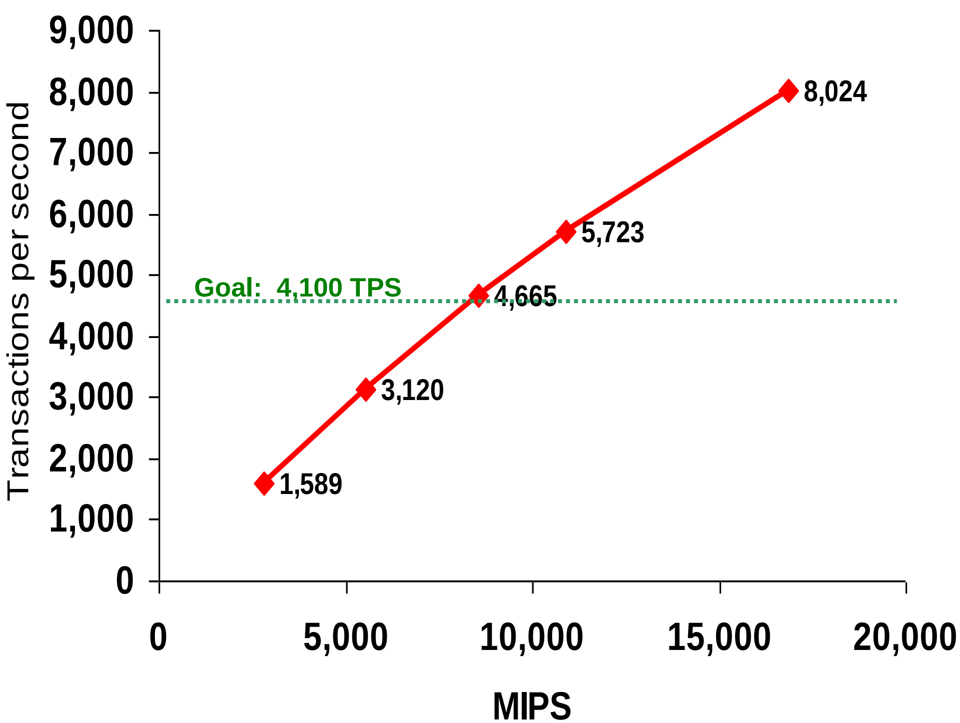


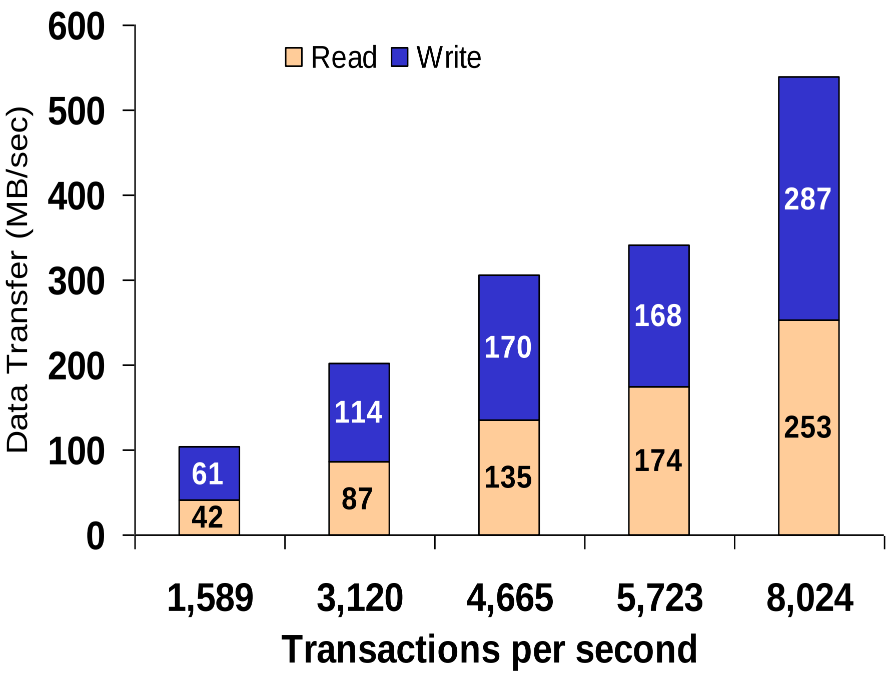
- **Up to 16 dedicated System Assist Processors (SAPs)**
  - All I/O requests are offloaded to SAPs
  - 16 SAPs can sustain up to **2.4M IOPS***
  - I/O subsystem bus speed of 8 GBps
  - Number of SAPs increases from 4 to 16 according to system size
- **Up to 160 physical FICON cards for I/O transfers**
  - Up to 320 RISC processors (2 per card)
  - Up to 320 FICON channels (2 per card)
  - 8 Gbps per link, 288 GB/Sec I/O aggregate per zEC12
- **IBM DS8800 Storage System**
  - Up to 440K IOPS capability
- **Delivers I/O efficiency at scale**

* Recommend 70% max utilization – 1.7M IOPS
Numbers represent High Performance FICON traffic

More Critical Data Workload Increases I/O Demand

Bank of China System z Benchmark required huge I/O bandwidth capacity

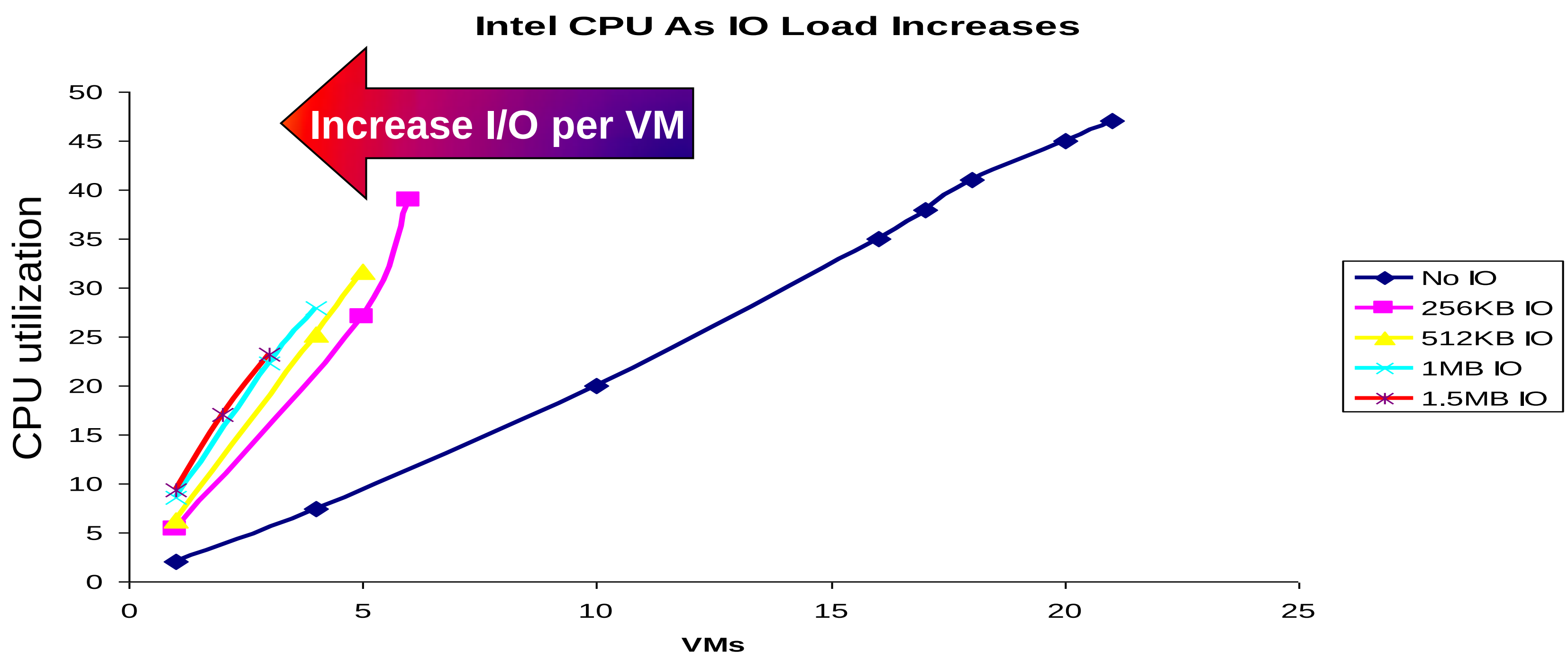




System z scaled smoothly despite increasing I/O demand

Intel Performance Degrades As I/O Demand Increases

- Test case scenario: Run multiple virtual machines on x86 server
  - Each virtual machine has an average I/O rate
  - Increasing the I/O rate uses more of the x86 processor for I/O processing
  - Therefore reducing the number of virtual machines that can be run



Source: CPO Internal Study. 12-core Westmere EP with KVM. FB at 22 tps with varying IO per transaction.

z/OS Database Workloads Benefit From Higher I/O Bandwidth

Competitor DB on Intel

SAP Applications

Database

8x 3850 x5 with 32 cores
(dual active clusters)

128 DB cores

DB2 on z/OS

SAP Applications

Database

zEC12 2-way data
sharing Sysplex

44 DB cores

14 ICF cores

41%** more postings at **½ cost!

Database Unit Cost
$0.30/Postings per hour

Postings per Hour	42.0M
# of Accounts	90M
Hardware	$0.63M
Software	$12.0M
Total (5 yr. TCA)	$12.6M

Database Unit Cost
$0.15/Postings per hour

Postings per Hour	59.1M
# of Accounts	150M
DB2 Solution Edition (HW+SW)	$7.49M
Capacity Backup (CBU)	$1.24M
Total (5 yr. TCA)	$8.73M

Cost of platform infrastructure for comparative transaction production. Cost of packaged application software not included. List prices used.

Linux On System z Workloads Also Benefit From Higher I/O Bandwidth

Comparison of consolidation platforms

Workloads

1 workload
per 16-core
x86 blade

Virtualized on x86
16 core HX5 Blade

48 workloads
per 32-way z/VM

I/O bandwidth large scale pool

Virtualized
on z/VM on zEC12
32 IFLs

***24x** more workload density than x86*

Online banking workloads, each driving **22** transactions per second, with **1 MB I/O per transaction**

What System z Can Do That Intel Can't

1. Run Bigger and More Workloads

2. Perfect Workload Management

Intel Sandy Bridge

System z

System z Has Perfect Workload Management

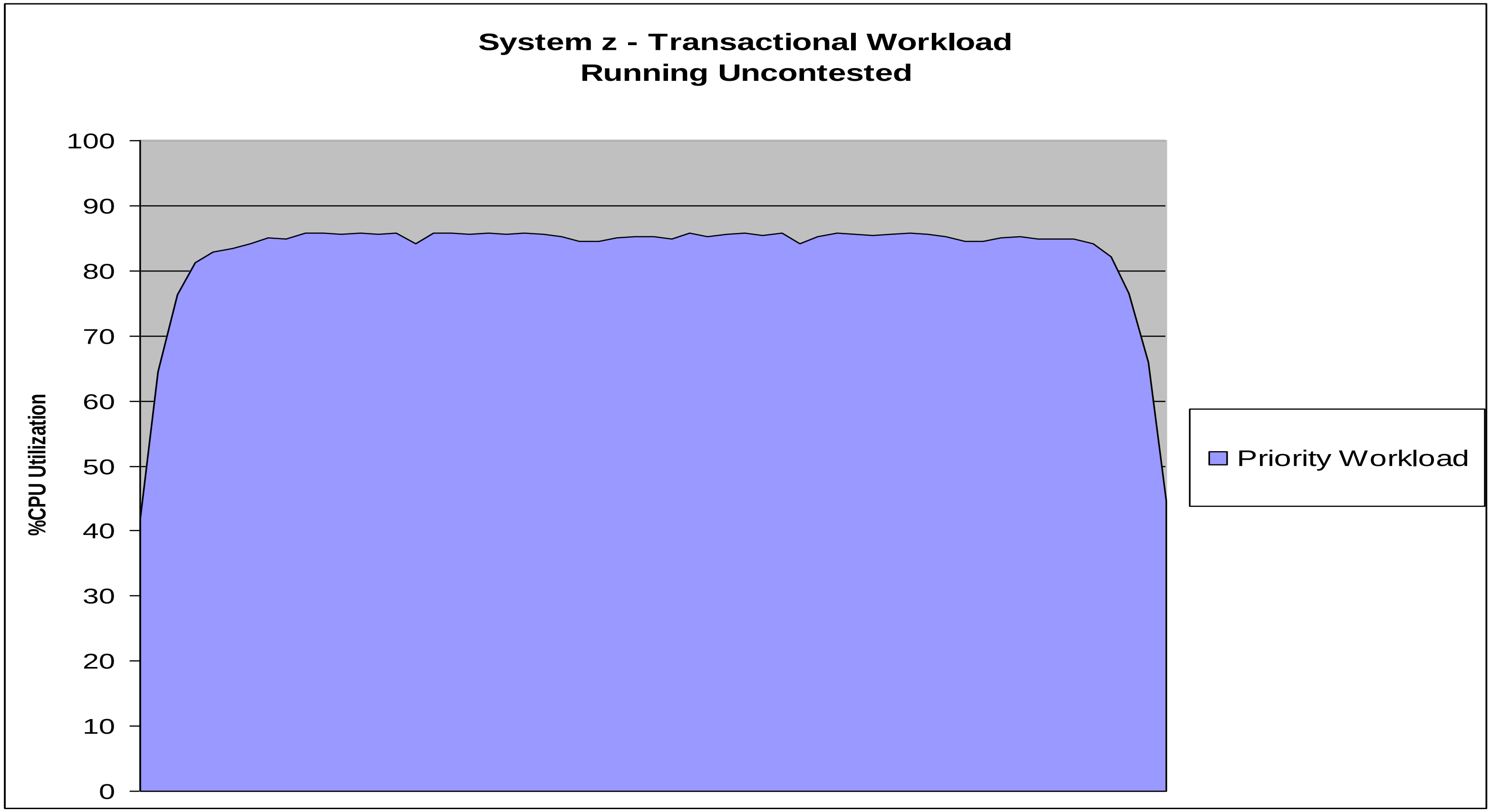
Intel can't do this

- z/OS Workload Manager (WLM) is perfect for processes
  - I/O subsystem extends prioritization to the storage disks
- PR/SM provides workload management across LPARs

Intel Sandy Bridge

System z

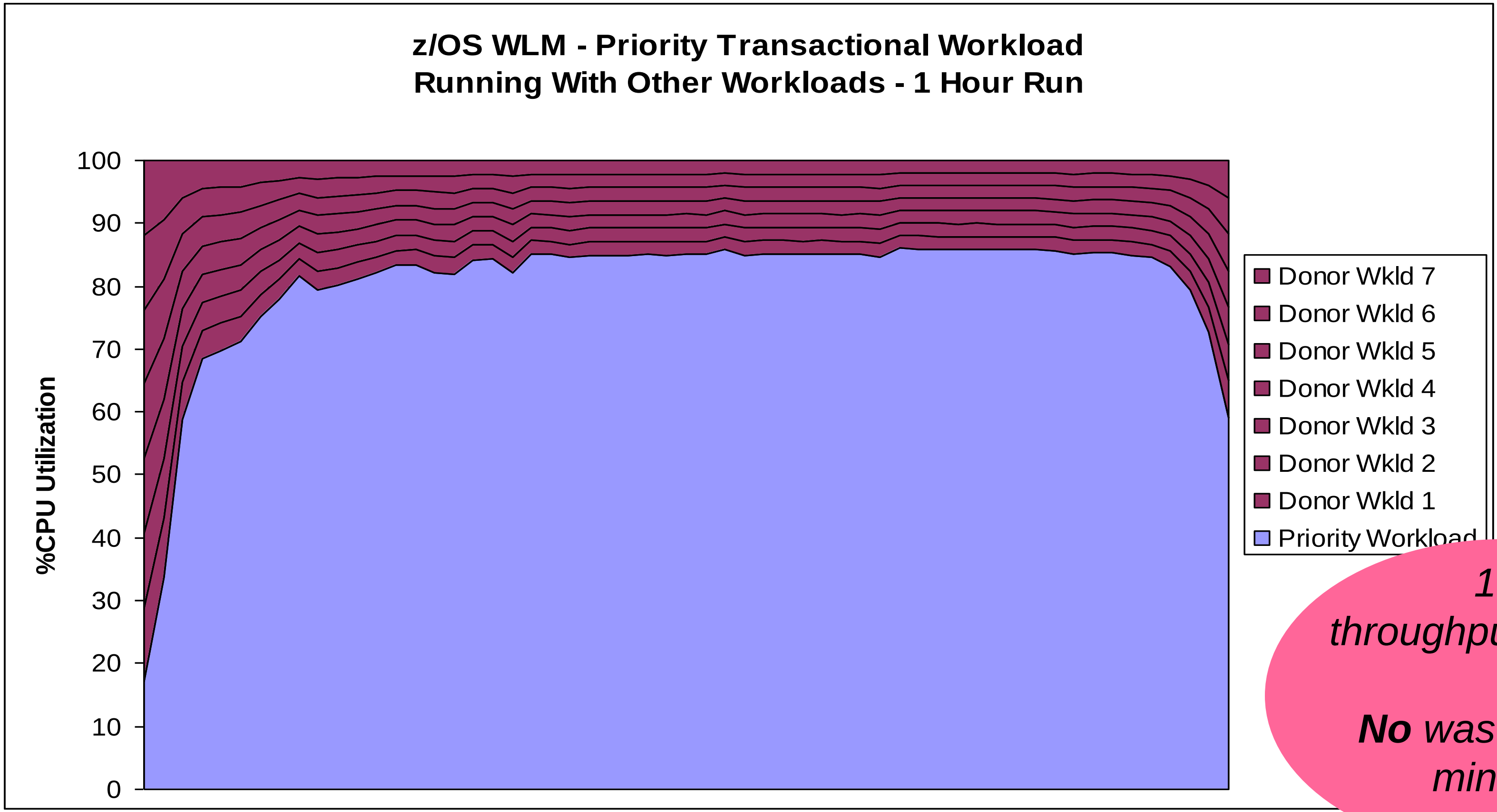
Priority Transactional Workload With Constant Demand Running Standalone On z/OS



Capacity Used
High Priority Steady State – 85.2% CPU Minutes
Unused (wasted) – 14.8% CPU Minutes

Priority Workload Metrics
Total Throughput: 418K

Priority Transactional Workload On z/OS Does Not Degrade When Low Priority Donor Workload Is Added



1% throughput leakage

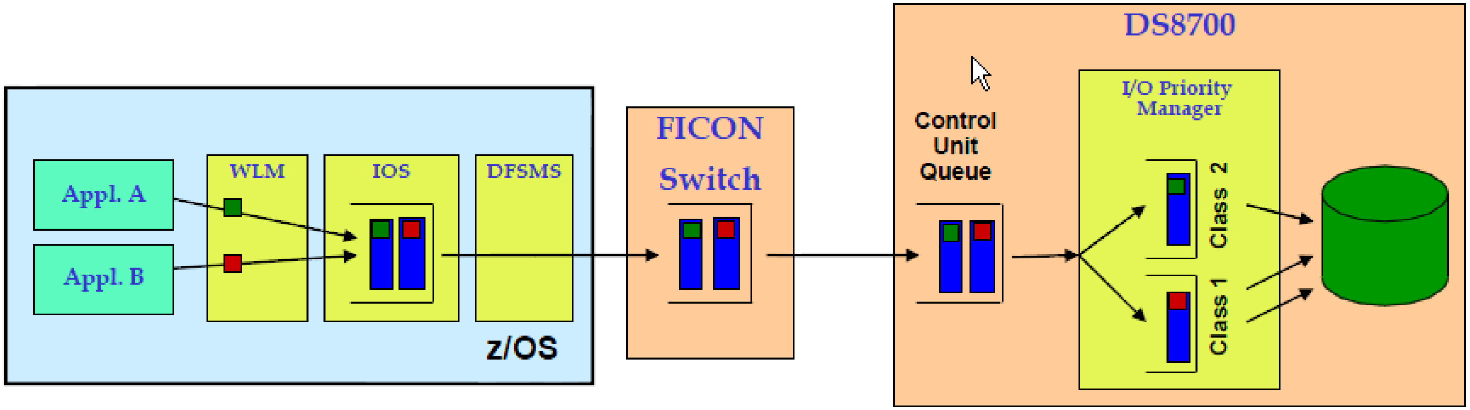
***No** wasted CPU minutes*

Capacity Used
High Priority Steady State – 85.3% CPU Minutes
Unused (wasted) – 0% CPU Minutes

Priority Workload Metrics
Total Throughput: 415K

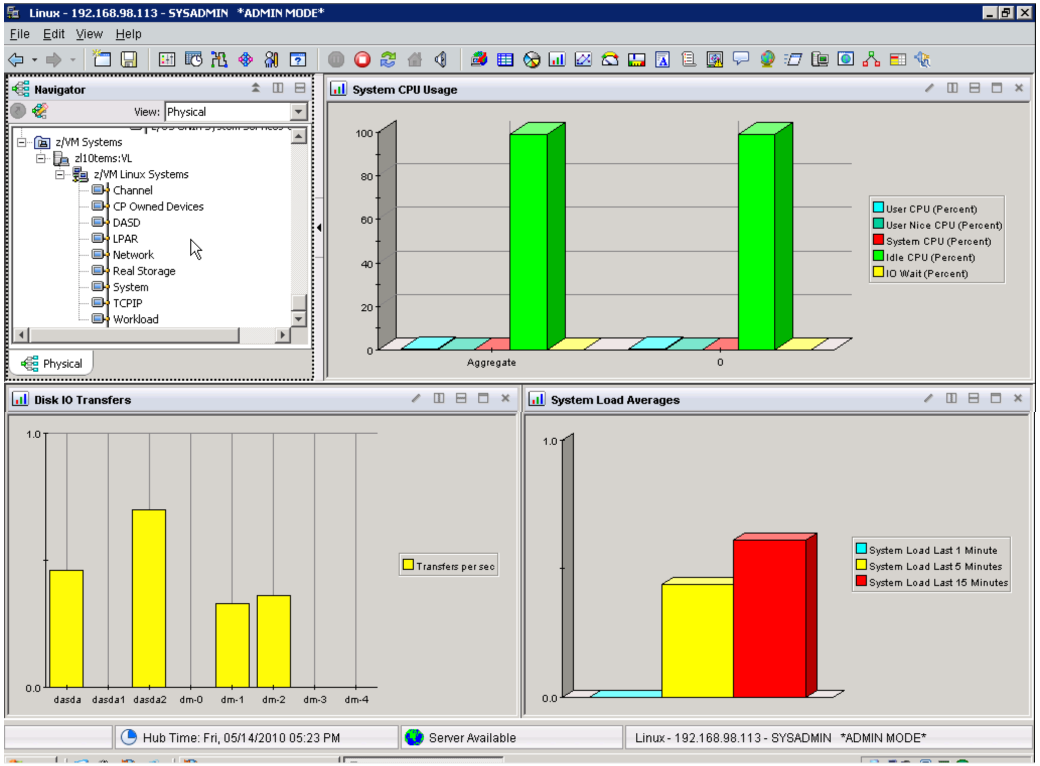
z/OS Workload Management Extends Priority All The Way Down To Storage

- FICON protocol supports advanced storage connectivity features not found in x86
- Priority Queuing:
  - Priority of the low-priority programs will be increased to prevent high-priority channel programs from dominating lower priority ones



Intel can't do this

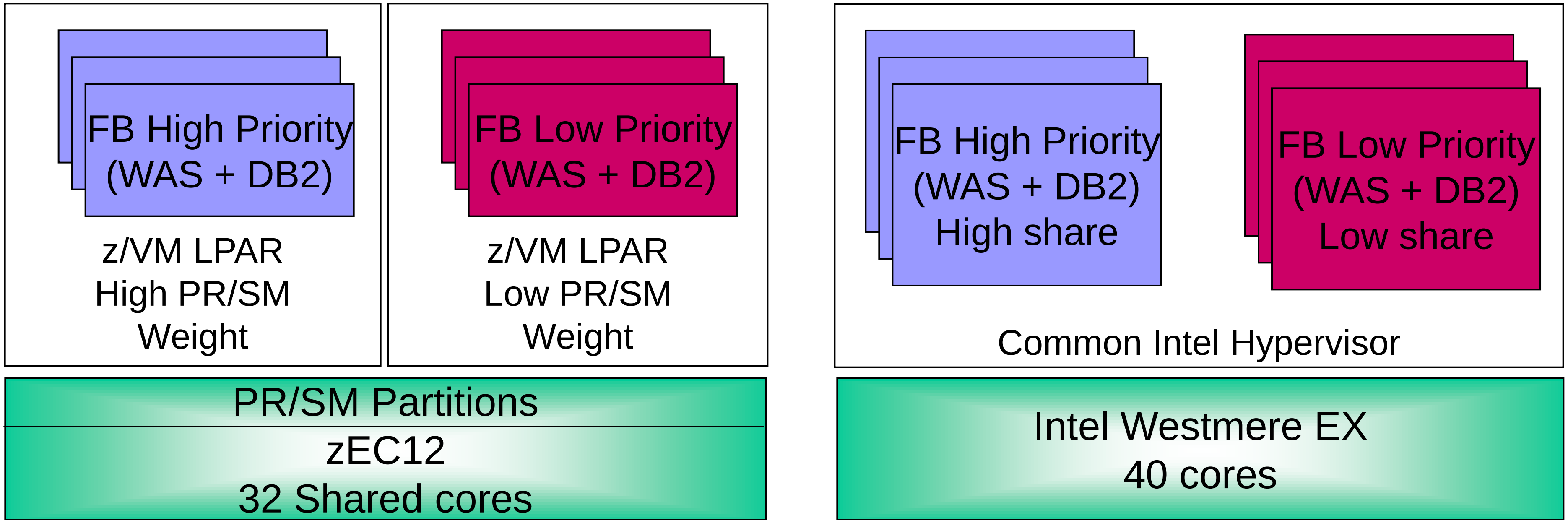
DEMO: z/OS Workload Management



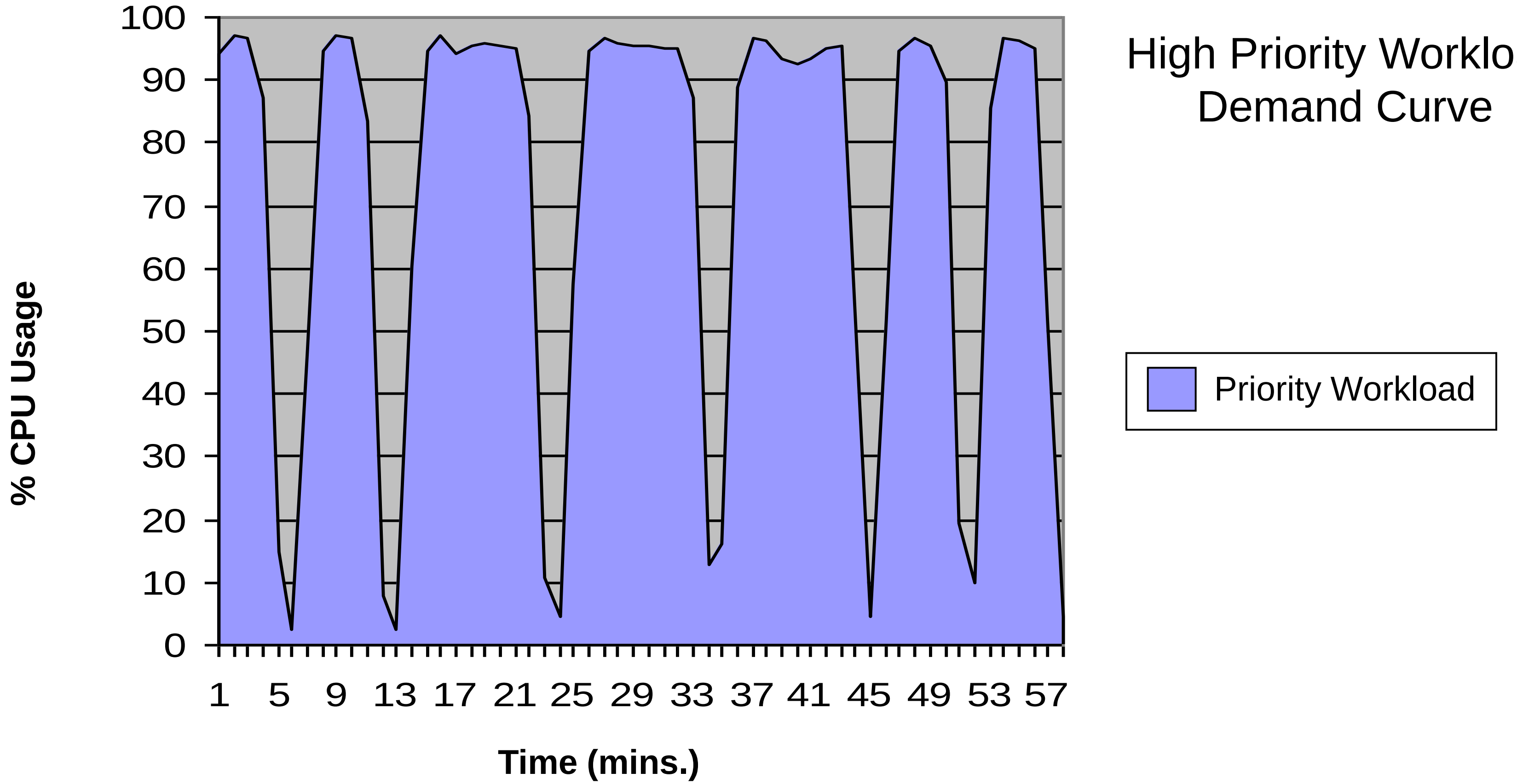
Comparison of System z PR/SM To Common Hypervisor Virtualization Environments

- High Priority web workload has defined demand over time
- SLA requires that response time does not degrade

- Low Priority web workload has unlimited demand
- It "soaks up" unused CPU minutes



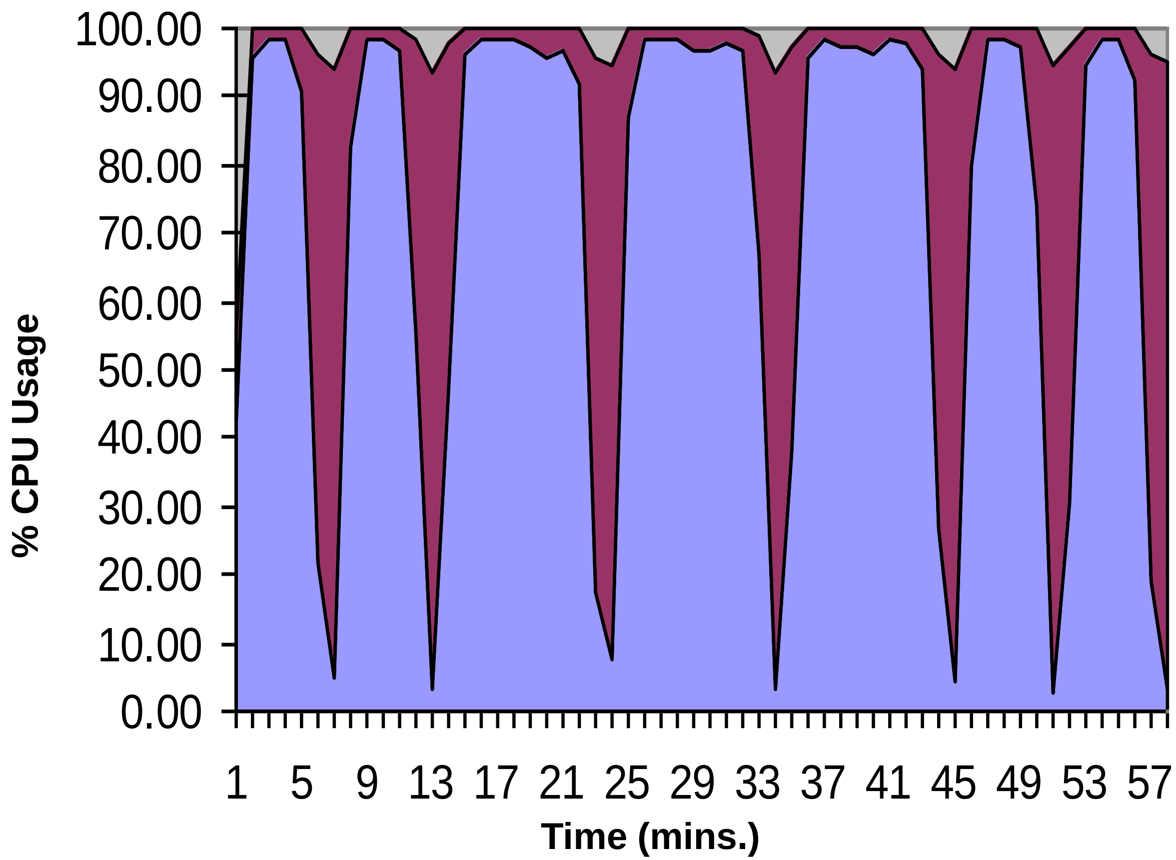
Priority Workload With Varying Demand Running Standalone On System z PR/SM



Capacity Used
High Priority – 72.2% CPU Minutes
Unused (wasted) – 27.8% CPU Minutes

Priority Workload Metrics
Total Throughput: 9.13M
Avg Response Time: 140ms

Priority Workload On System z Does Not Degrade When Low Priority Donor Workload Is Added



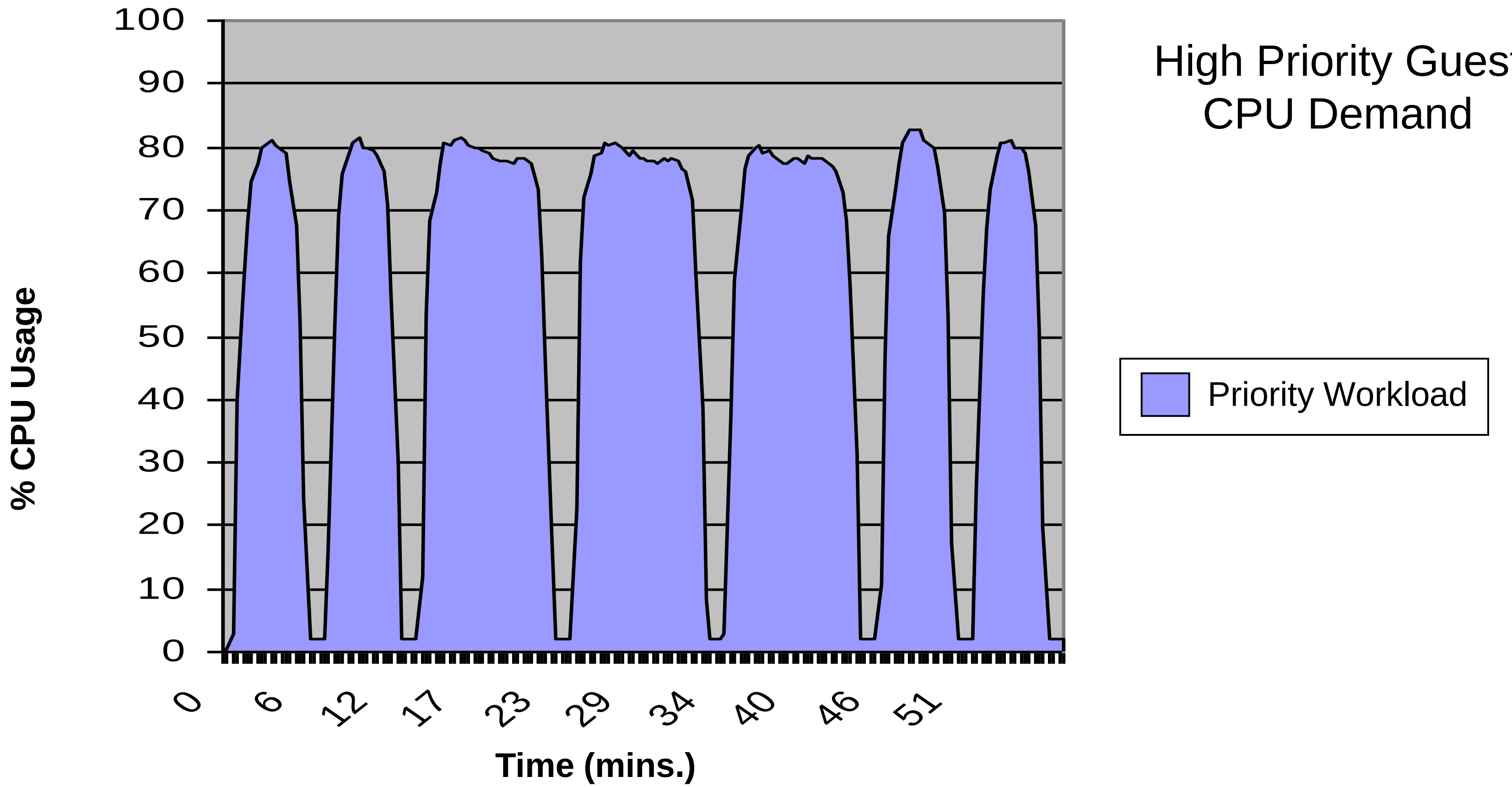
Run High Priority And Low Priority Workloads Together

NO throughput leakage
NO response time increase

Capacity Used
High Priority – 74.2% CPU Minutes
Low Priority – 23.9% CPU Minutes
Wasted – 1.9% CPU Minutes

Priority Workload Metrics
Total Throughput: 9.13M
Avg Response Time: 140ms

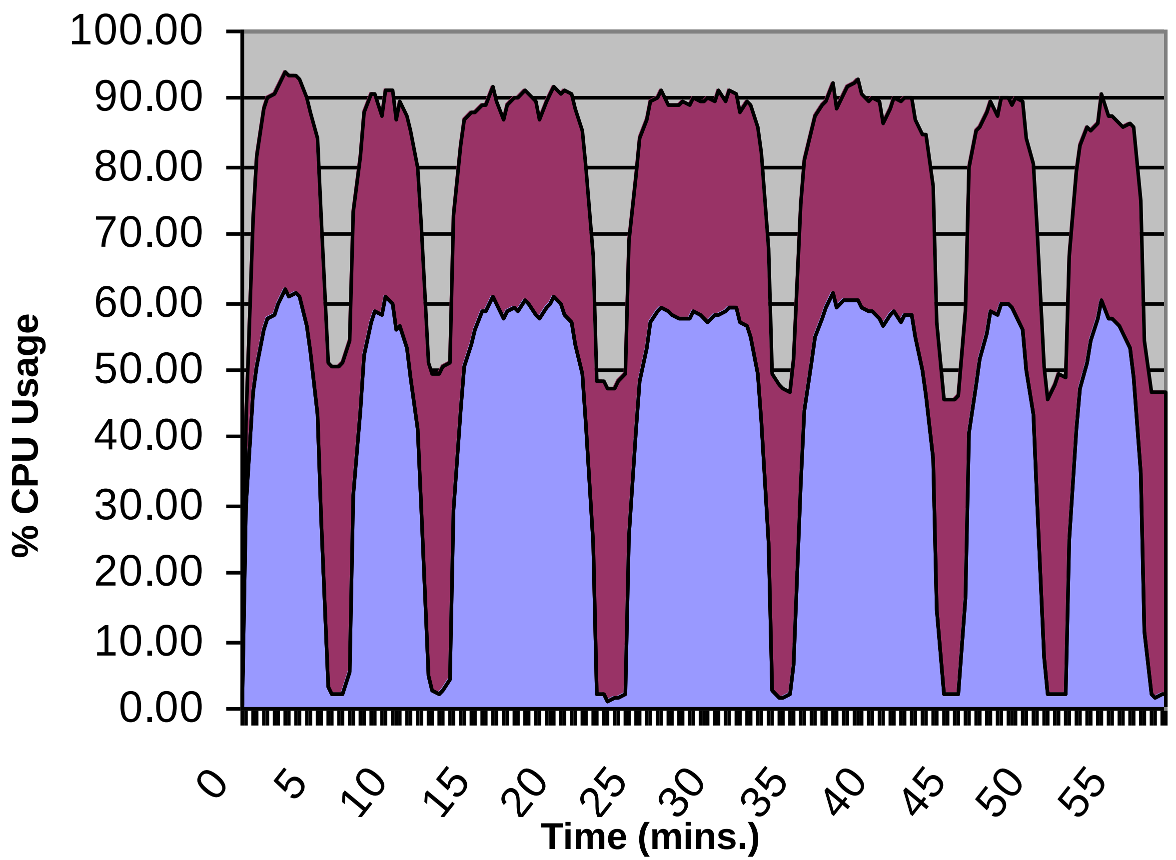
Priority Workload With Varying Demand Running Standalone On Common Hypervisor



Capacity Used
High Priority – 57.5% CPU Minutes
Unused (wasted) – 42.5% CPU Minutes

Priority Workload Metrics
Total Throughput: 6.47M
Avg Response Time: 153ms

Priority Workload On Common Hypervisor Degrades Severely When Low Priority Workload Is Added



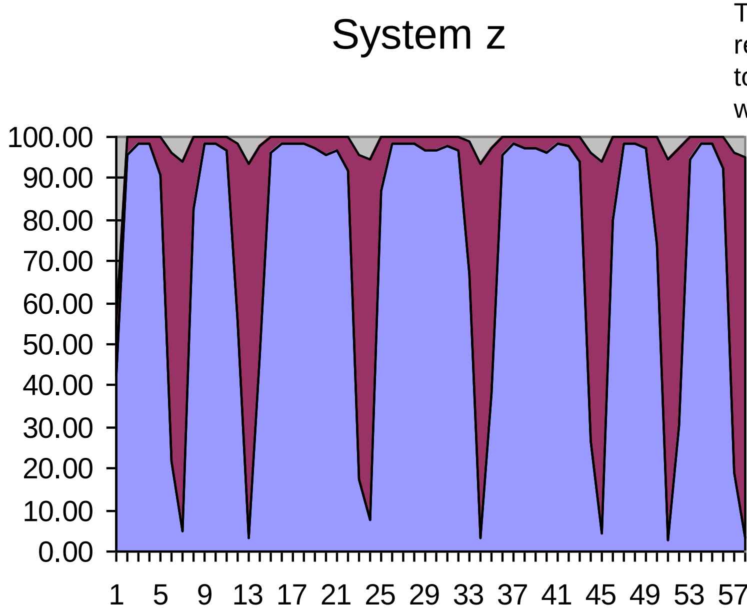
Run High Priority And Low Priority Workloads Together

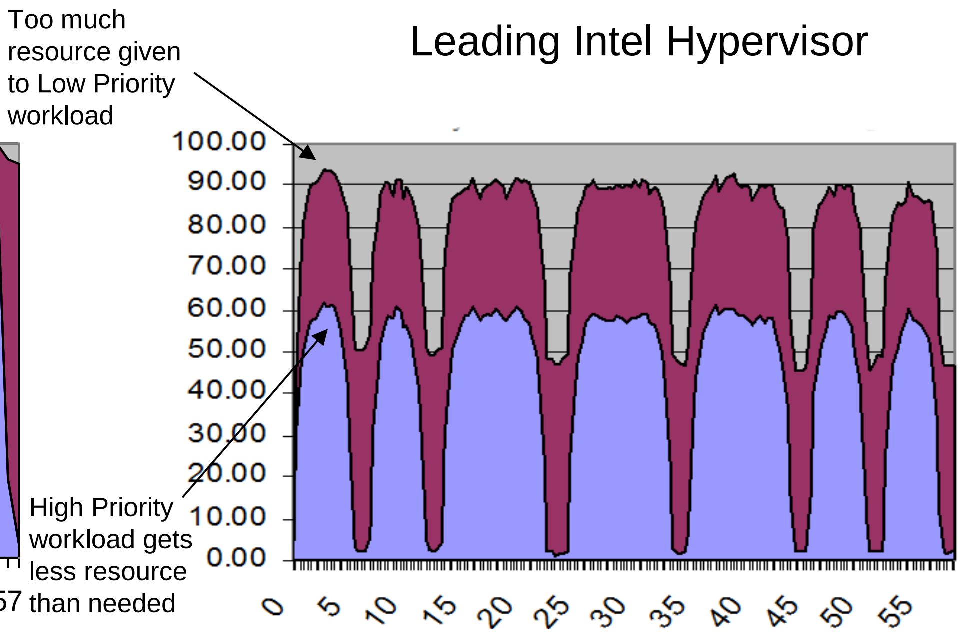
30.7%
throughput leakage
45.1%
response time increase
21.9%
wasted CPU minutes

Capacity Used
High Priority – 42.3% CPU Minutes
Low Priority – 35.8% CPU Minutes
Wasted – 21.9% CPU Minutes

Priority Workload Metrics
Total Throughput: 4.48M
Avg Response Time: 220ms

System z Virtualization Enables Mixing Of High And Low Priority Workloads Without Penalty

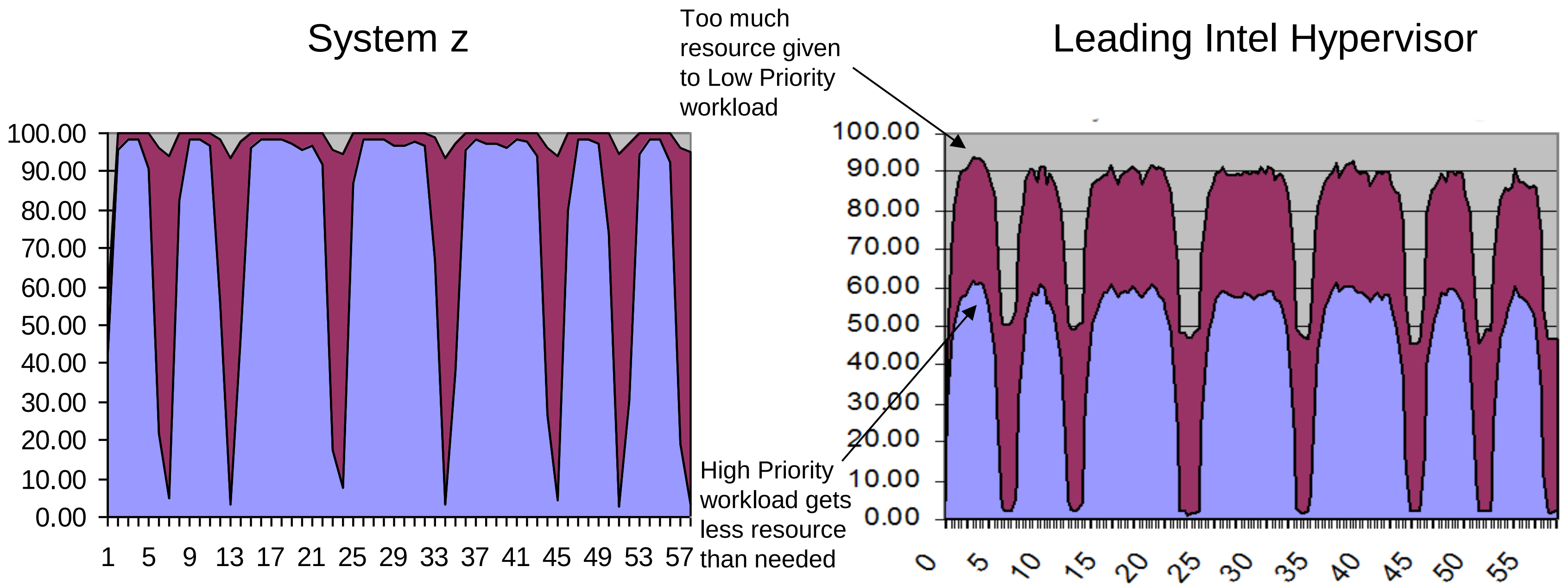




- Priority Workload
  - No throughput reduction
  - No response time increase
- Low Priority Workload
  - Soaks up remaining CPU minutes
- Unused CPU minutes 1.9%

- Priority Workload
  - 31% throughput reduction
  - 45% response time increase
- Low Priority Workload
  - Soaks up more CPU minutes
- Unused CPU minutes 21.9%

System z Virtualization Enables Mixing Of High And Low Priority Workloads Without Penalty

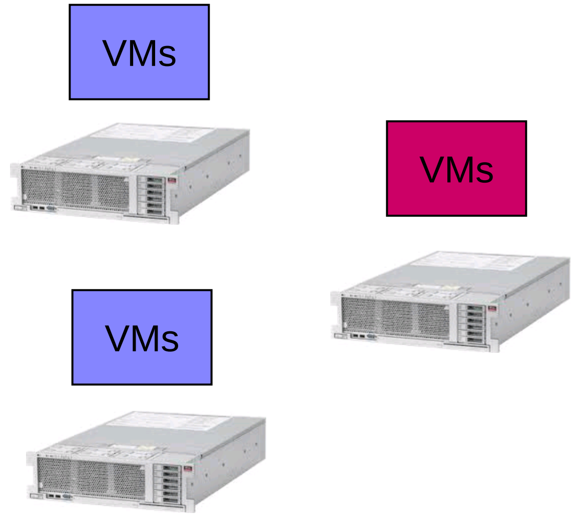


- Perfect workload management
- Consolidate workloads of different priorities on the same platform
- Full use of available processing resource (high utilization)

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

Deliver High And Low Priority Workloads Together While Maintaining Response Time SLA

Comparison to determine which platform provides the lowest TCA over 3 years



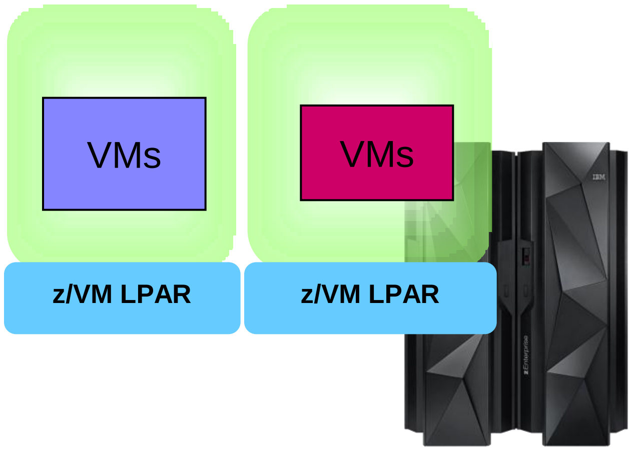
Virtualized on 3 Intel 40 core servers

$13.7M (3 yr. TCA)

High priority workloads

Low priority workloads

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



z/VM on zEC12

32 IFLs

$5.77M (3 yr. TCA)

58% lower cost!

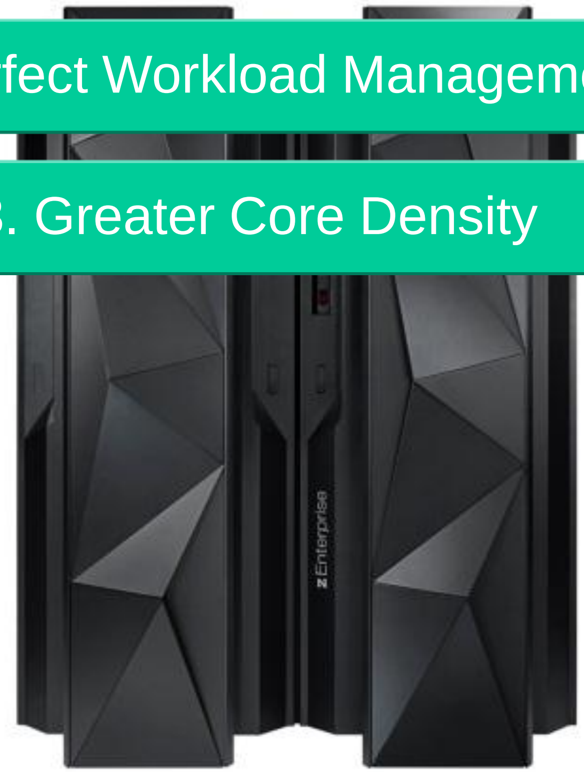
High priority online banking workloads driving a total of **9.1M** transactions per hour and low priority discretionary workloads driving **2.8M** transactions per hour

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.

What System z Can Do That Intel Can't

1. Run Bigger and More Workloads
2. Perfect Workload Management
3. Greater Core Density

Intel Sandy Bridge



System z

Why Core Proliferation Happens When Moving Workload From System z To Intel

- De-consolidation of applications to dedicated servers – decomposing highly tuned co-located components
- 4x pathlength expansion moving from CICS/COBOL applications
  - 3x expansion when converting hierarchical databases to relational
- Functional segregation into production, development and test
- 100% hardware coverage for Disaster Recovery costs double

Intel Sandy Bridge

System z

Core Proliferation For A Large Workload

16x 32-way HP Superdome
App. Production / Dev / Test

8x 48-way HP Superdome
DB Production / Dev /Test

zEC12 41-way Production / Dev / Test

***41* GP processors**
(38,270 MIPS)

***896* processors**
(3,668,600 Perf Units)

***22x** more cores!*

$180M (5 yr. TCA)

$111M (5 yr. TCA)

NOTE: To cover DEV/QA capacity, add 100% servers for distributed servers, add 25% MIPS (8,000) to System z

Core Proliferation For A Mid-sized Workload

6x 8-way Production / Dev
2x 64-way Production / Dev
Application/MQ/DB2/Dev partitions

2x z900 3-way Production / Dev / QA / Test

6 processors
(1,660 MIPS)

176 processors
(800,072 Performance units)

$25.4M (5 yr. TCO)

$17.9M (5 yr. TCO)

***29x** more cores!*

482 Performance Units per MIPS

Core Proliferation For Oracle Workloads

Benchmark study for a Media and Entertainment Industry customer

107 HP servers

1440 cores total

***30x** more cores!*

Hardware	$2.9M
Software	$24.2M
Labor	$7.9M
Space, Power and cooling	$1.2M
Disaster Recovery	$6.5M
Total (5 yr. TCO)	**$42.7M**

zEC12

48 IFLs

1 PS701

1 HX5

Hardware	$4.9M
Software	$8.5M
Labor	$1.8M
Space, Power and cooling	$0.5M
Disaster recovery	$4.8M
Total (5 yr. TCO)	**$20.5M**

Intel: Oracle DB + App costs = $13.1M (LIC + maint over 5 yrs.).
IBM: Oracle DB + App costs = $1.92M (LIC + maint over 5 yrs.)

Migration Offloads Have Additional Costs

Typical Eagle TCO Study For A Financial Services Customer

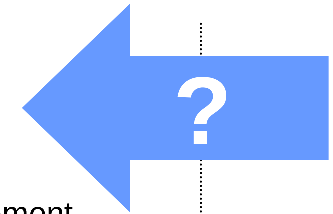
x86 – 4 HP Proliant DL 980 G7 servers

Production

Development

256 cores total

Hardware	$1.6M
Software	$80.6M
Labor (additional)	$8.3M
Power and cooling	$0.04M
Space	$0.08M
Disaster Recovery	$4.2M
Migration Labor	$24M
Parallel Mainframe costs	$31.5M
Total (5 yr. TCO)	**$150M**



System z z/OS Sysplex

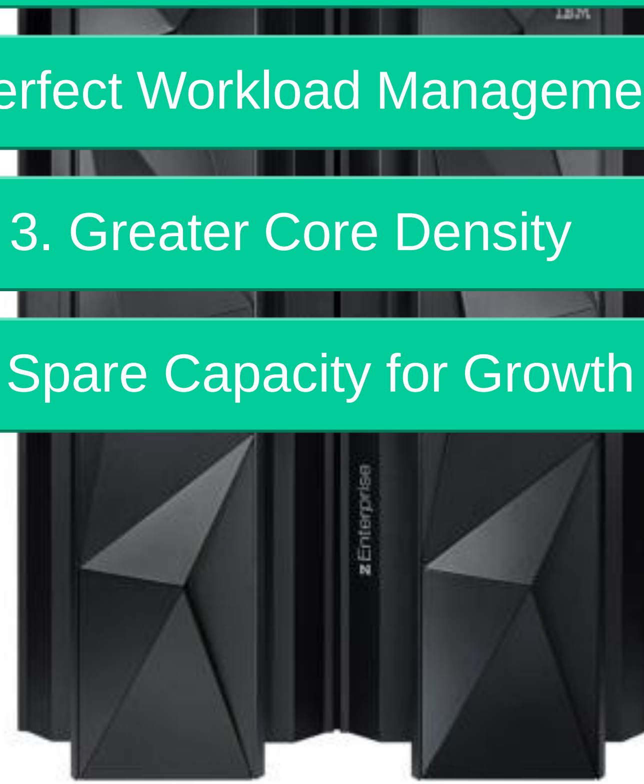
2,800 MIPS

Hardware	$1.4M
Software	$49.7M
Labor	Baseline
Power and cooling	$0.03M
Space	$0.08M
Disaster recovery	$1.3M
Total (5 yr. TCO)	**$52M**

What System z Can Do That Intel Can't

Intel Sandy Bridge

1. Run Bigger and More Workloads
2. Perfect Workload Management
3. Greater Core Density
4. Spare Capacity for Growth



System z

System z's Integrated Capacity On Demand (CoD) Extends To Storage

- System z ships with spare processors installed
  - Capacity on Demand can turn on spare processors without service interruption
  - **Intel can't do this**

System z

- Capacity on Demand extends to DS8870
  - Up to six standby disk drive sets (96 disk drives total) can be concurrently field-installed into the system*
  - Non-disruptive activation
  - Easy to logically configure the disk drives for use – no IBM intervention required
  - Midrange storage typically used by **Intel can't do this**

DS8870

*SSDs not available for CoD configurations

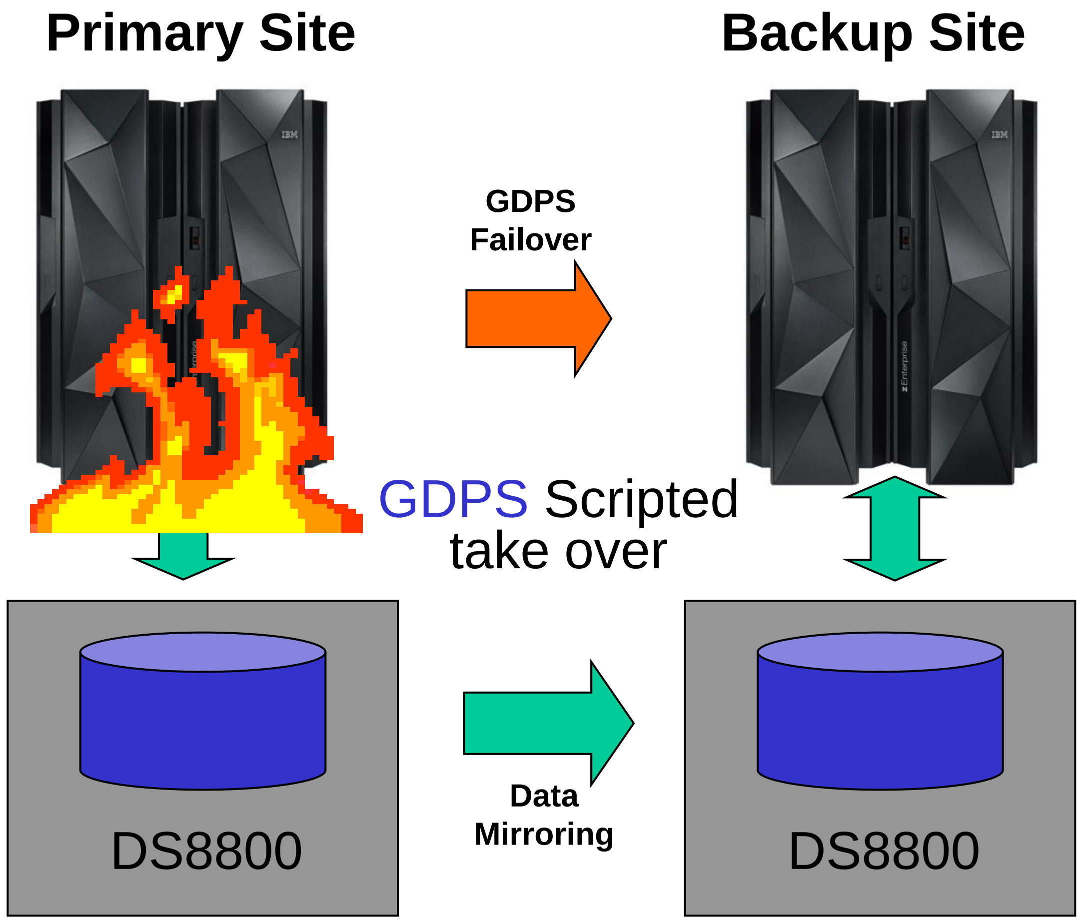
What System z Can Do That Intel Can't

Intel Sandy Bridge

1. Run Bigger and More Workloads
2. Perfect Workload Management
3. Greater Core Density
4. Spare Capacity for Growth
5. Comprehensive Disaster Recovery

System z

System z Disaster Recovery Is Systematic And Comprehensive

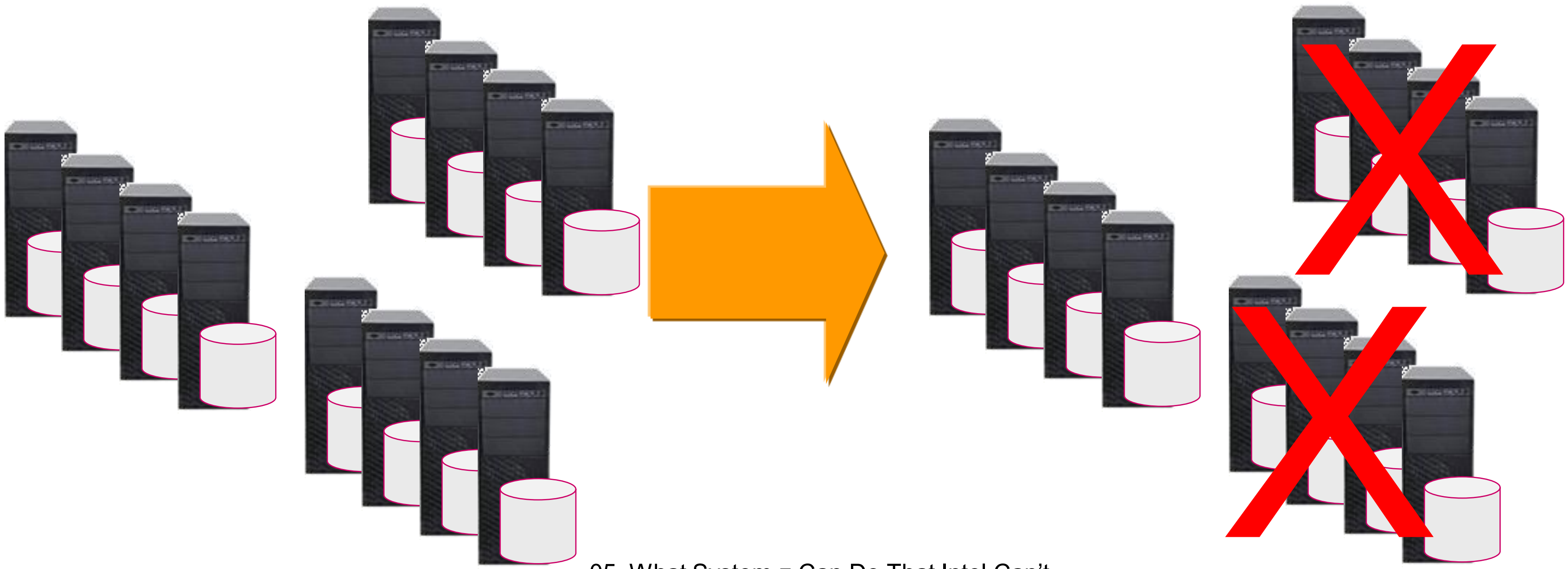


- Site Failover
  - Failover to secondary site in case of complete site failure
- Data Mirroring
  - Protect data in the event of a disk system failure
- All workloads fully covered

Supports systematic Disaster Recovery for virtualized Linux environments also

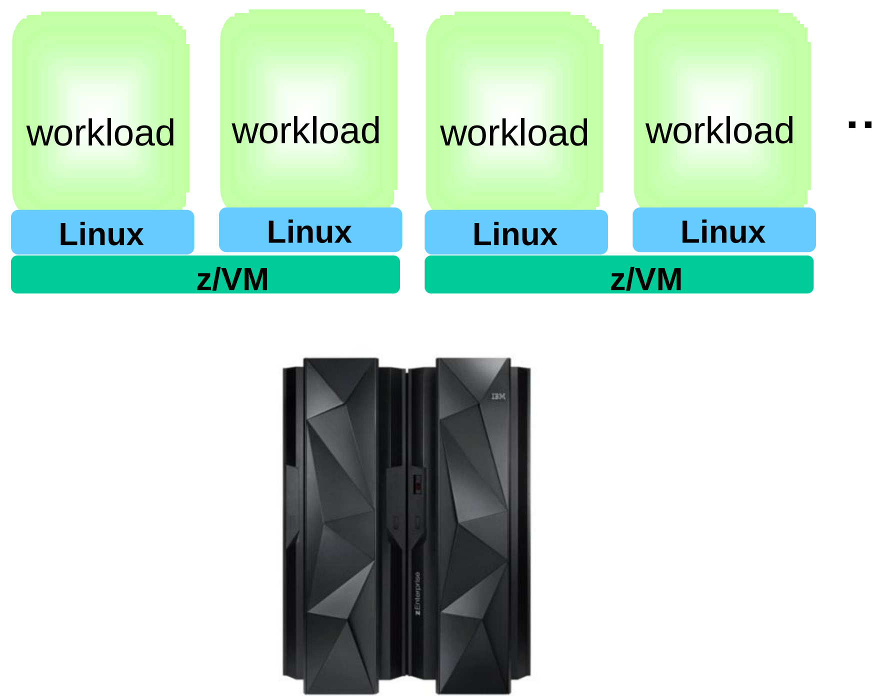
Complexity Of Intel Disaster Recovery Solutions Inhibits Wide Spread Use

- Workloads on standalone Intel servers require a disaster recovery solution for each server
  - Data mirroring
  - Failover and restart
- Embedded storage is difficult to mirror
- Different middleware recovery mechanisms
- Only 20% workloads covered
- Comprehensive workload failover infeasible for hundreds of servers



Consolidation Of Workloads On System z Simplifies Disaster Recovery

- Workloads are consolidated onto z/VM partitions as Linux guests
- Linux on System z can be failed over as part of GDPS



What System z Can Do That Intel Can't

Intel Sandy Bridge

1. Run Bigger and More Workloads
2. Perfect Workload Management
3. Greater Core Density
4. Spare Capacity for Growth
5. Comprehensive Disaster Recovery
6. Runs Longer without Stopping

System z

System z Has More Comprehensive Protection To Ensure Better Availability Than Intel

System z Reliable Operations

Error Detection
- Error detection/ correction codes
- Data capture

Error Prevention
- Failure analysis
- Burn-in
- Shake test

Recovery
- Scan path
- Spare CPU
- Sysplex failover
- Channel

Change Management
- Non-disruptive
- Hardware
- Software

Service Element
- Problem determination
- Problem isolation

Maintenance
- “Phone Home”
- Local parts depot
- Local service

Example:
zEC12 Provides Transparent CPU Sparing

- Transparent sparing for all CPU types
  - CP, ICF, IFL, zAAP, zIIP
- zEC12 has 2 spare CPUs per server
  - Spares do not have to be local to the same book
- Processor Availability Facility (PAF) saves state and switches to spare CPU
  - Error detection circuits detect a failing processor
  - Failing processor is stopped
  - Data contents of failing processor are transferred to spare processor
    - Scan register technology
  - Processing resumes on spare processor
  - NO apparent interruption to the workload

Intel can’t do this

Example: Redundant Array Independent Memory

- Intel protects against the seen:

  Historical failures, like:
  - DRAMs (soft and hard)
  - Single interface lanes,
  - Limited coverage on buffer chips

- z196/zEC12 also protects against the unforeseen:
  - DRAMs
  - Single interface lane errors
  - Full bus failures
  - Buffer chips (hard and soft errors)
  - DIMM wipeouts
  - DIMM connectors
  - Boards
  - Clock failures

Intel can't do this

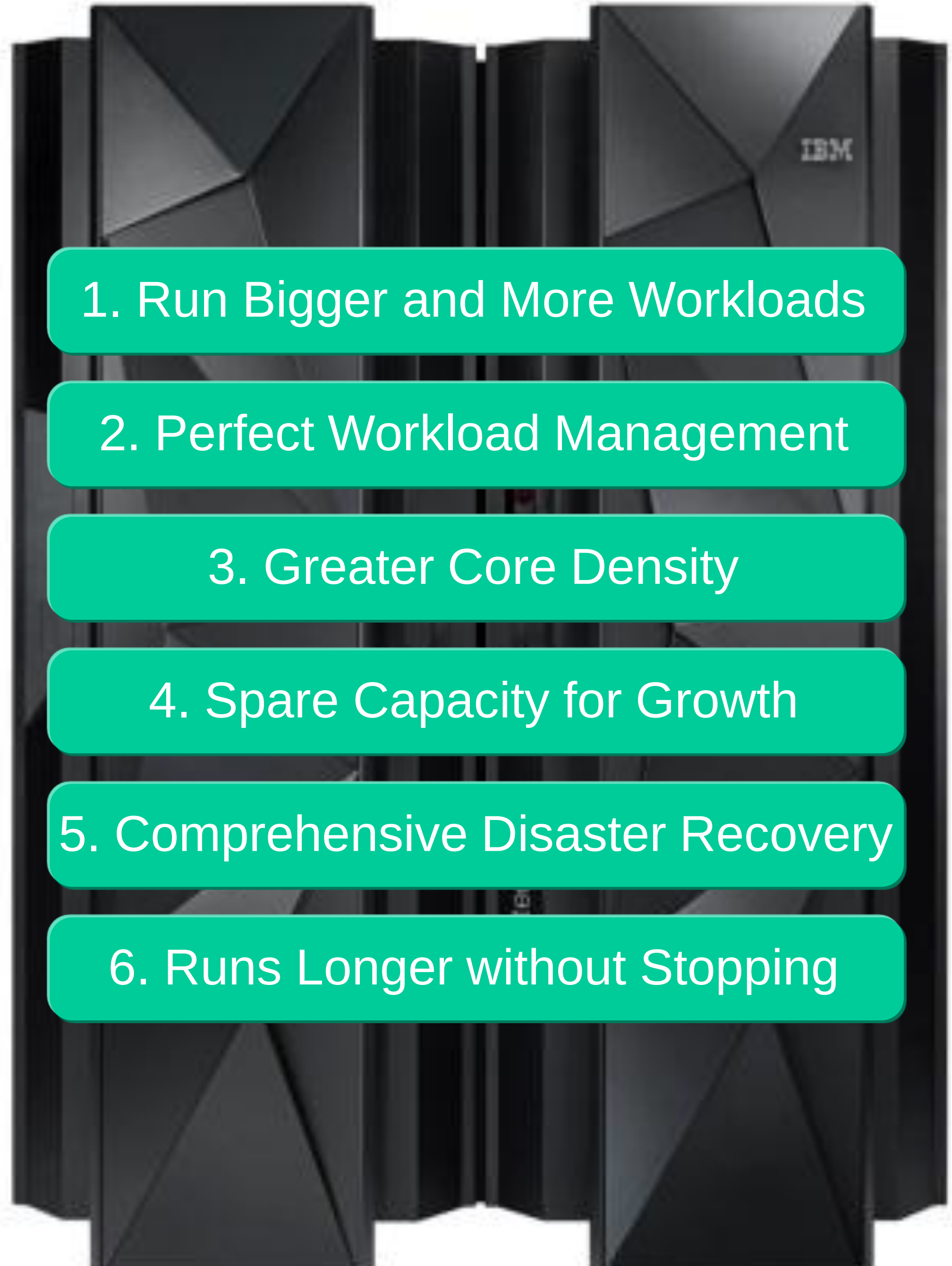
System z Supports Concurrent Operations During Hardware Repair – *Intel Can't*

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 to replace core, memory controllers, cache, etc.
Memory Replacement	While Running	Must bring server down to replace
Memory Bus Adaptor Replacement	While Running	Must bring server down to replace
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

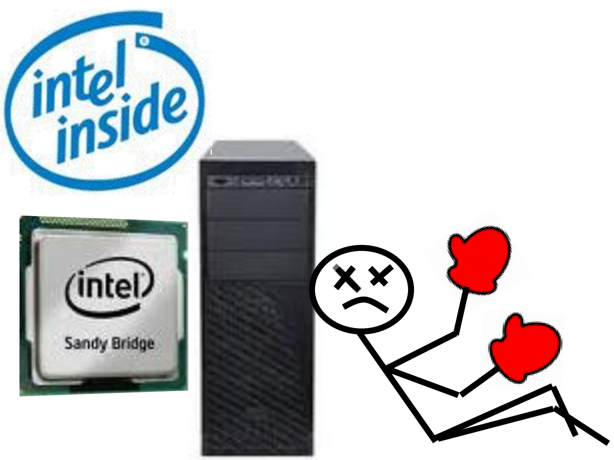
Single book systems may not support concurrent memory upgrades

The Choice Is Clear!

System z
is better than Intel
for Systems of Record



1. Run Bigger and More Workloads
2. Perfect Workload Management
3. Greater Core Density
4. Spare Capacity for Growth
5. Comprehensive Disaster Recovery
6. Runs Longer without Stopping



Notice Regarding Specialty Engines (e.g., zIIPs, zAAPs and IFLs):

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