Consolidate Diverse Workloads
On POWER And Save

IBMDiscoveryDays**2011**

Copies of Today's Presentations:
http://www.ibm.com/developerworks/offers/techbriefings/details/power.html
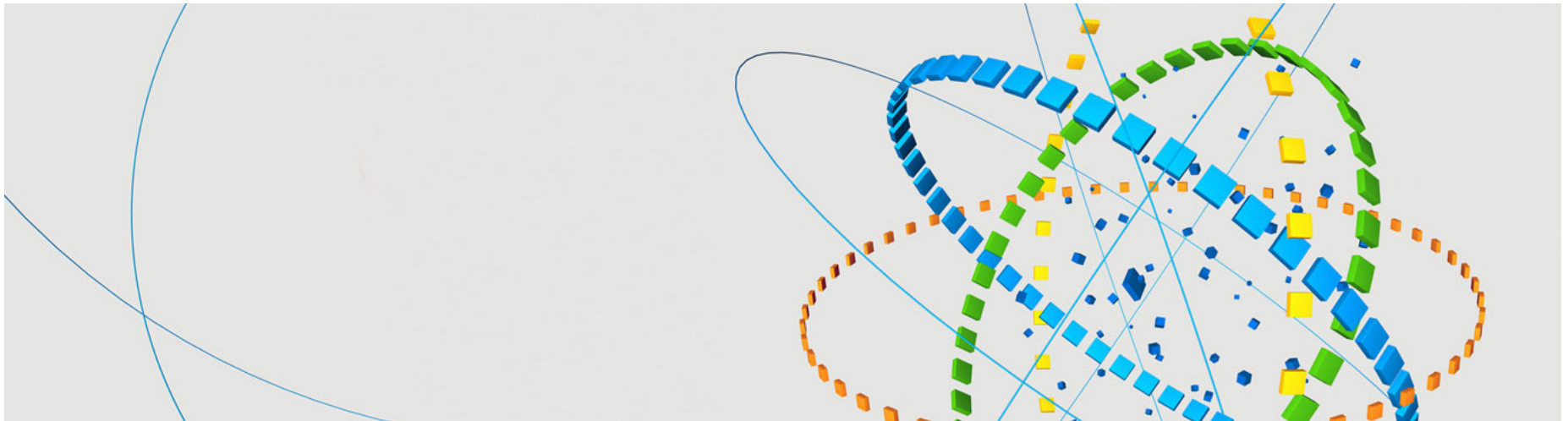
Virtualize And Consolidate To Easily Achieve The Lowest Cost Per Workload

IBM Software
Manage with VMControl and IBM Systems Director

- Tivoli. software
- Lotus. software
- Rational software
- WebSphere. software
- Information Management

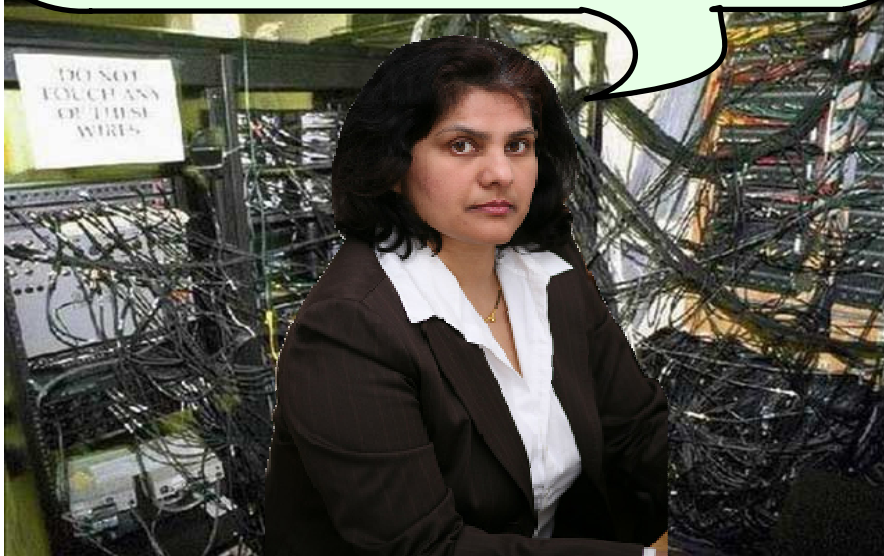## IBM Power Systems
Integrated POWER hypervisor efficiency and superior virtualization offer massive consolidation and drives costs down

Cost per Workload

Increasing Utilization per Server
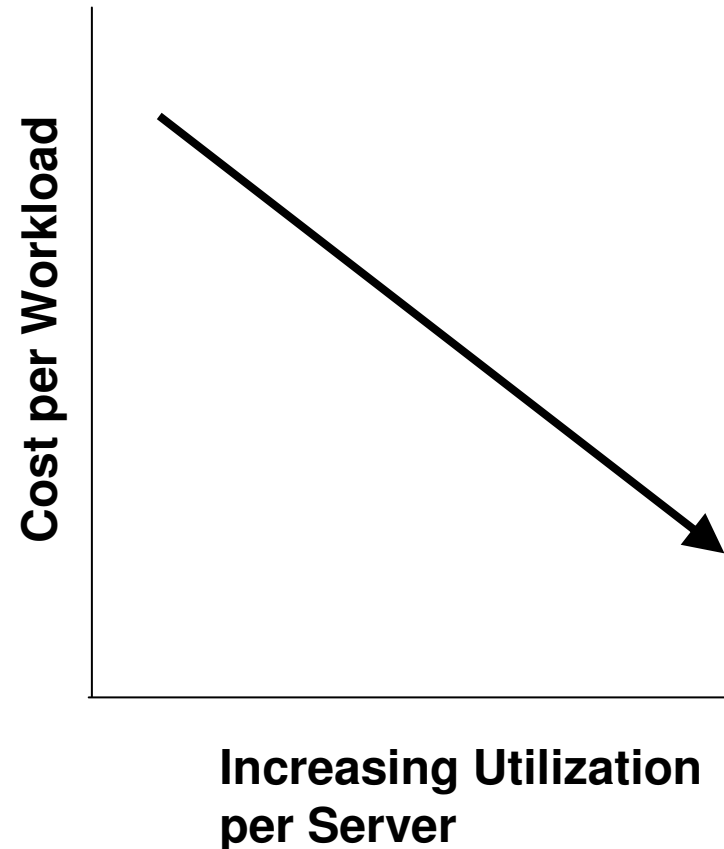
Achieving The Lowest Costs Per Workload

Consolidation through server virtualization is a powerful way to shrink our server footprint and save.

That is just part of the value that Power Systems server virtualization brings to your organization … Let me prove it to you!

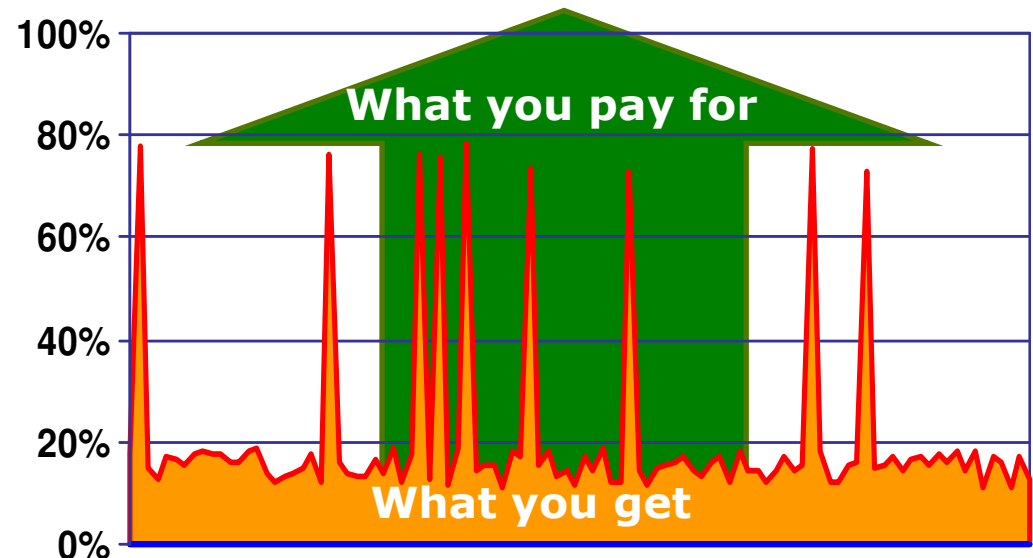**Service Oriented Finance CIO**

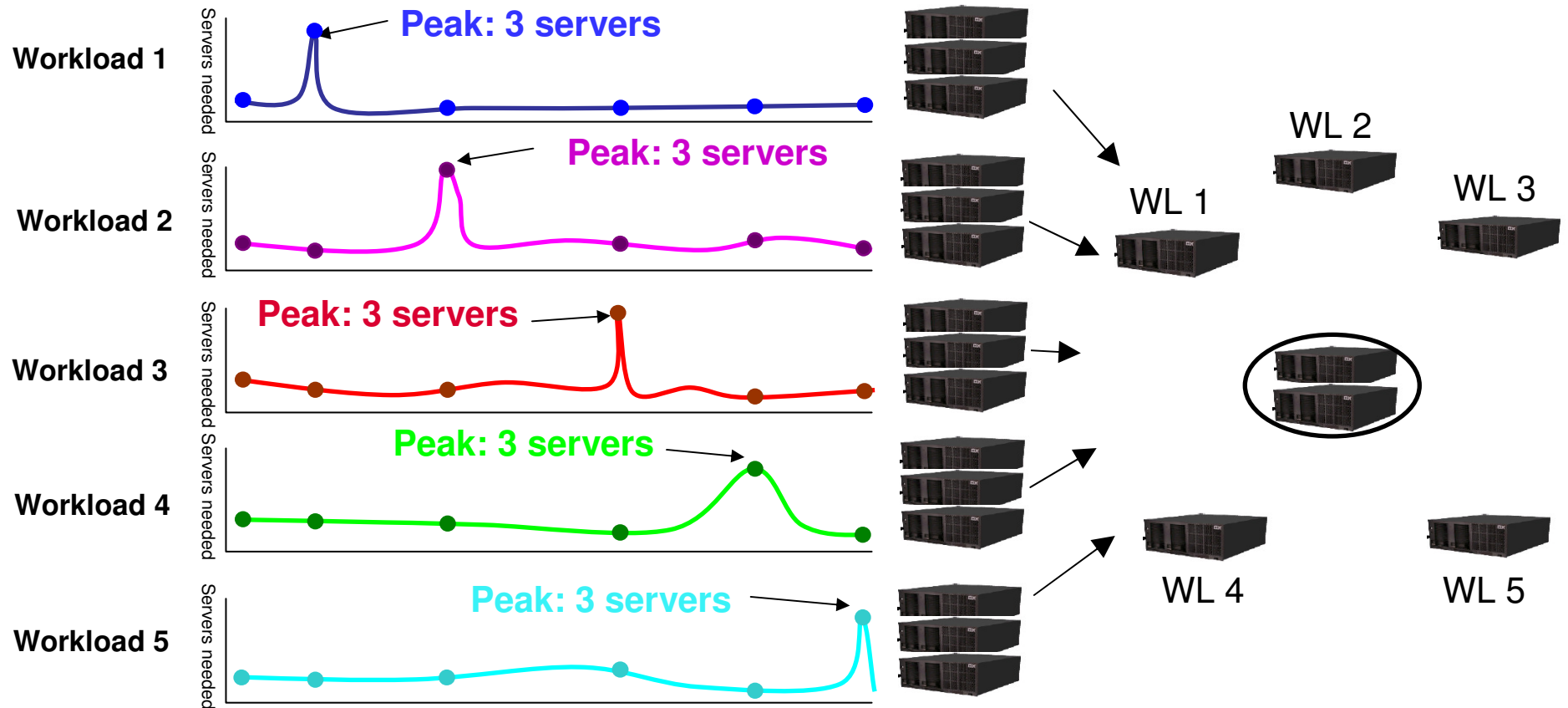**IBM**

Low Utilization Drives Up Cost

The typical UNIX or x86 serving running a single operating environment is only 10 - 20% utilized

- System waits for I/O and memory access even when it is working

- Configuration planned for peaks

- Configuration planned for growth

What you pay for

What you get

100%
80%
60%
40%
20%
0%

Result is that 80% of the hardware, software licenses, maintenance, floor space, and energy that YOU pay for, is wasted

How Virtualization Helps Consolidation

Workload 1

Servers needed

Peak: 3 servers

Workload 2

Servers needed

Peak: 3 servers

Workload 3

Servers needed

Peak: 3 servers

Workload 4

Servers needed

Peak: 3 servers

Workload 5

Servers needed

Peak: 3 servers

WL 1

WL 2

WL 3

WL 4

WL 5

A robust hypervisor can do this type of resource sharing with CPU's, Memory, Networks and I/O

Power Systems Virtualization Is Part Of The Platform Design, And Has Been Since 2001

PowerVM™

*IBM Mainframe hypervisor built into Power from the ground up ***

PowerVM is combination of hardware and firmware that provides CPU, memory, network and disk virtualization

- **Best performance which means lowest cost per workload**
  - ▶ Hypervisor is integrated into POWER7 Hardware
  - ▶ No software overhead or "fix as you go" on the platform components

- **Richest set of capabilities for Flexibility**
  - ▶ All components (CPU, Memory, Network, I/O) are aware of virtualization environment and managed dynamically

- **Integrated Dynamic Management System**
  - ▶ Based on System Director
  - ▶ CPU, Memory, Network, I/O

- **Impenetrable Security and Reliability**
  - ▶ Addressed at design – not an add-on
  - ▶ Integrated into the firmware and hardware
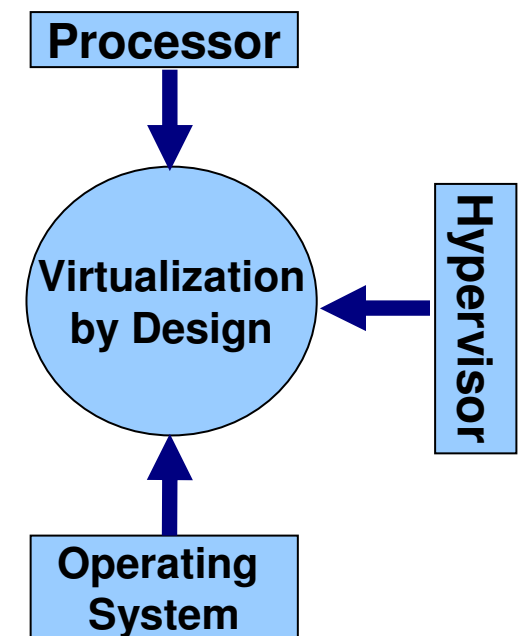
* News Flash:
1967 - IBM develops the world's first **hypervisor** called "VM" for S/360

Processor → Virtualization by Design ← Hypervisor

Operating System → Virtualization by Design

# Not All Hypervisor Solutions Are Created Equal! PowerVM Far Exceeds The Pack

The In-Memory Virtual Ethernet enables high speed memory to memory networking between partitions.

Logical Partitions (LPARs) are virtual servers that provide operating system and application isolation.

The Virtual I/O server (VIOS) enables virtual servers to share I/O hardware.

| VIOS | AIX 6 (or earlier) | SUSE Linux | WPAR WPAR AIX 7.1 | Red Hat Linux | IBM i |

POWER Hypervisor ™

Power Systems SMP Server

AIX allocates resources to Workload Partitions (WPARs).

Shared Storage

Shared access to disk storage and to external networks.
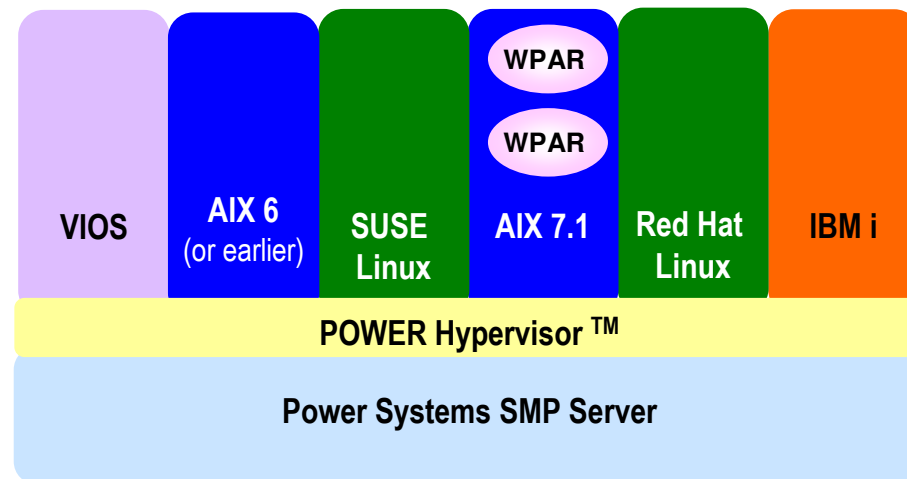
The Power Hypervisor shares processing resources among LPARs with up to 1024 dispatchable threads on 256 processors.
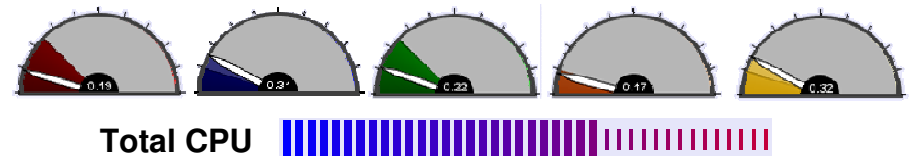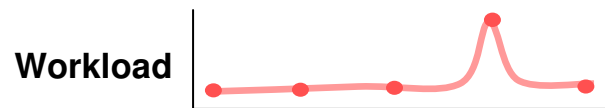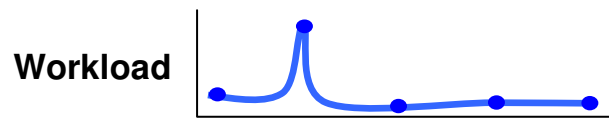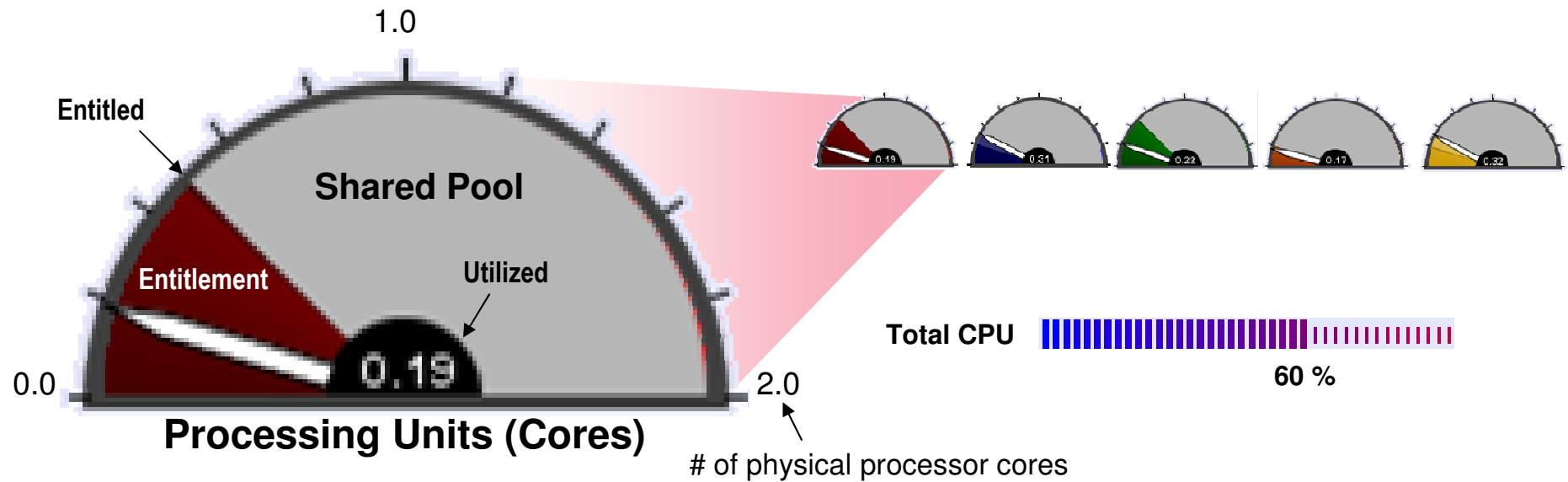
PowerVM™

Virtualization Without Limits

| Scaling Factors	PowerVM	Oracle VM for SPARC	VMware ESX 4.0 *(in VMware vSphere 4.1)*
Maximum VMs per server	1000	512	320
Virtual CPUs per VM	256	64	8
Memory per VM	8192 GB	512GB	255 GB
Maximum CPU threads per physical server	1024	512	64
Maximum Memory per physical server	8192 GB	512GB	1024 GB

IBM Power Systems better equipped to handle all types of virtualized workloads

DEMO: PowerVM – Dynamically Adjusting Processor Resources

1.0

Entitled

Shared Pool

Entitlement

Utilized

0.19

0.0

2.0

Processing Units (Cores)

# of physical processor cores

Total CPU

60 %

Workload

Workload

Total CPU

Power Systems **Memory** Is Also Virtualized And Shared With PowerVM

- Dynamically adjusts memory available on a physical system for multiple virtual images based on their workload activity levels:
  - Different workload peaks due to time zones
  - Mixed workloads with different time of day peaks (e.g. CRM by day, batch at night)
  - Ideal for highly-consolidated workloads with low or sporadic memory requirements

- Available with PowerVM Enterprise Edition
  - Supports AIX, IBM i and Linux workloads

- Blends Power Systems hardware, firmware and software enhancements to optimize resources
  - Supports over-commitment of logical memory
  - Overflow managed by VIOS paging device
  - Two VIOS partitions can be used for redundancy
  - Compatible with Live Partition Mobility
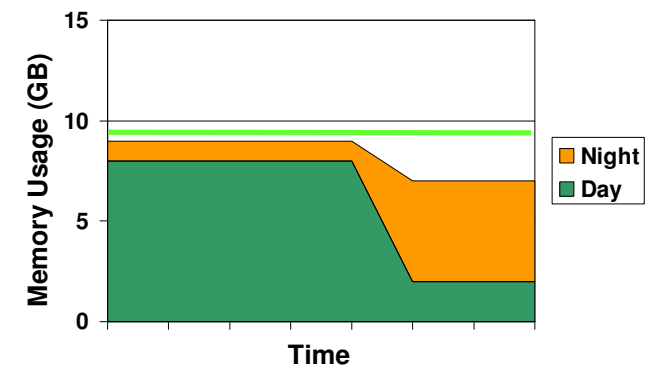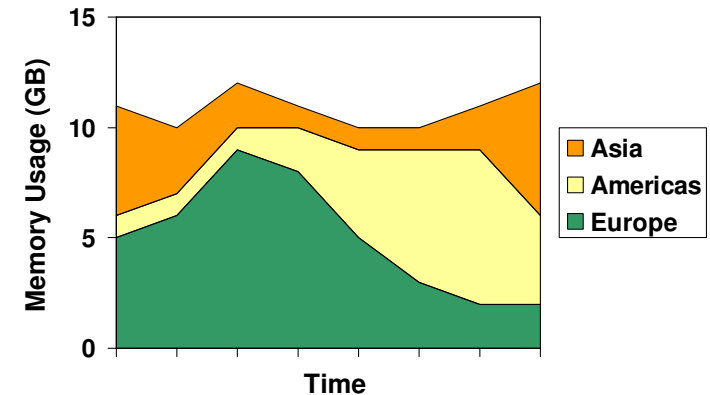
Active Memory Expansion: AIX LPARs Can Improve System Utilization And Increase Performance

- Compression of in-memory data is handled by the operating system

- Memory Expansion Factor determines by how much memory is expanded

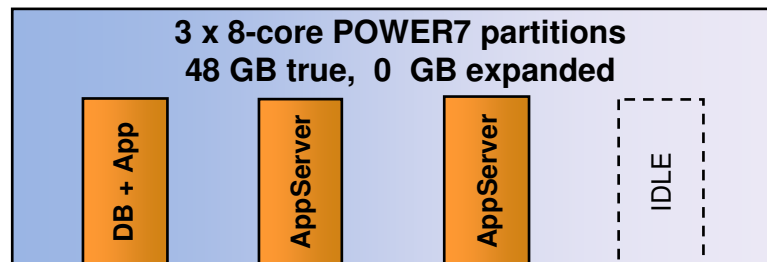- Active Memory Expansion is configurable on a per-logical partition (LPAR) basis

20 GB ← AME → **30 GB**

LPAR's Actual Memory **LPAR's Effective Memory**
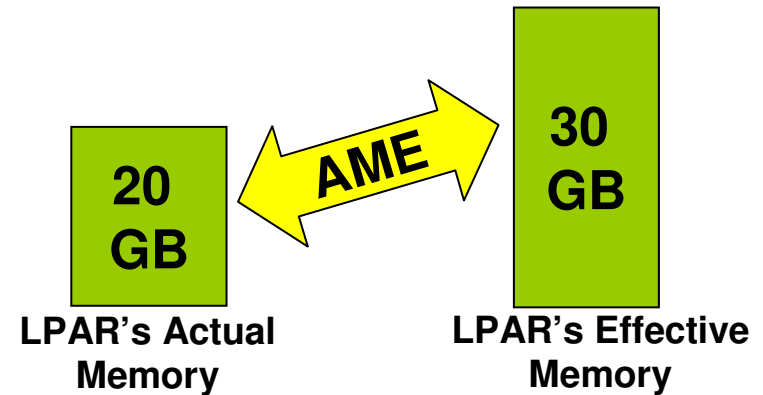
Without Active Memory Expansion

System Utilization
- Memory: 100% (48 GB) **- Bottleneck**
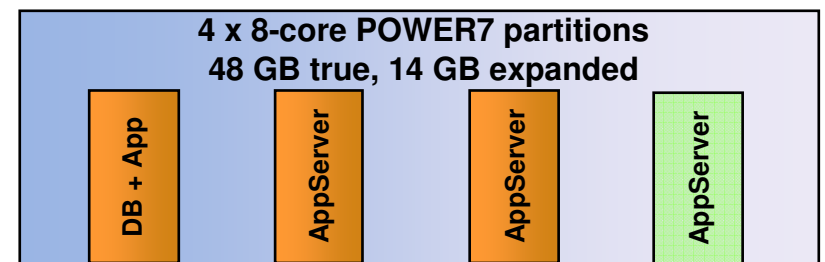- CPU: 76% of 32 cores

With Active Memory Expansion

System Utilization
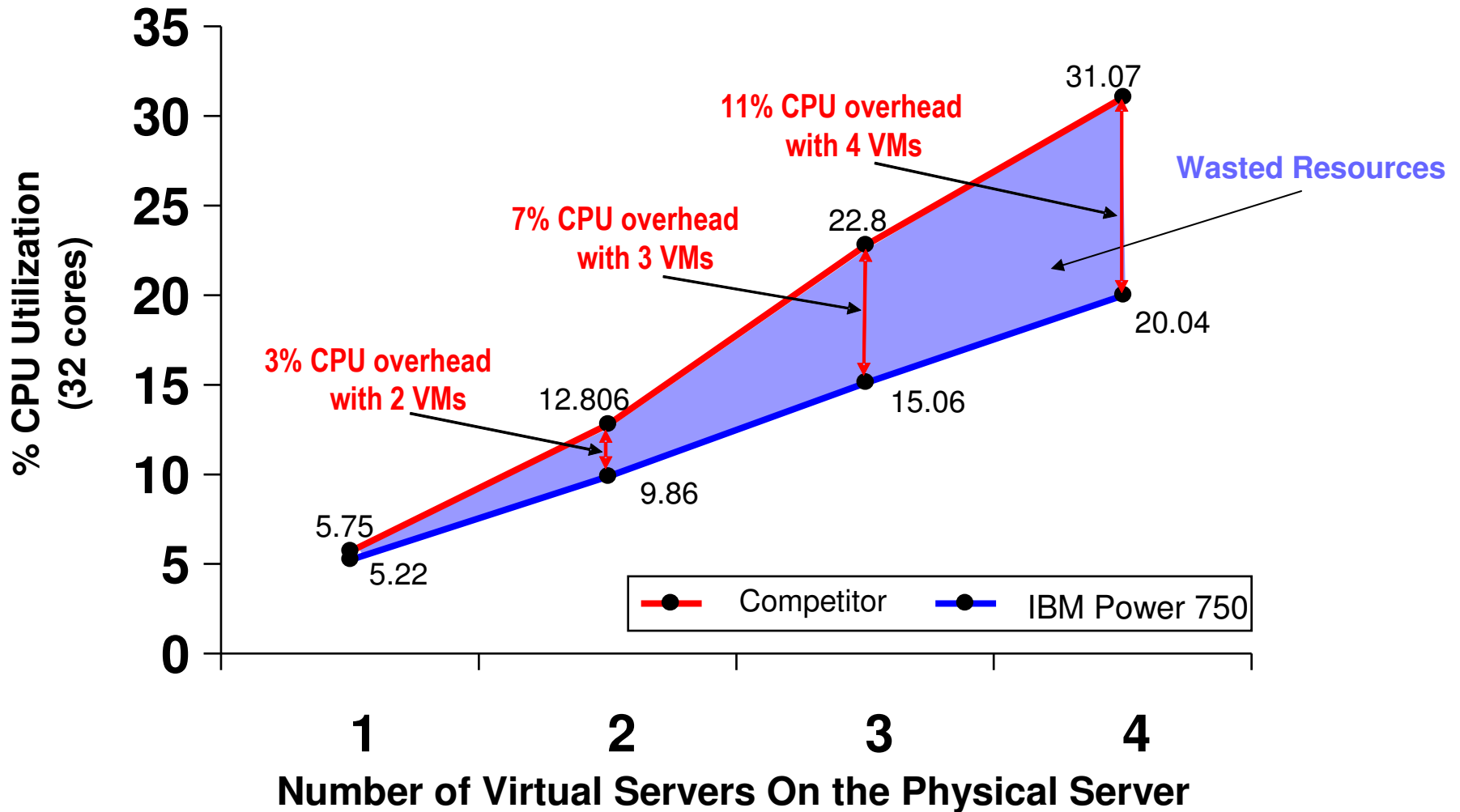- Memory: 100% (48 GB)
- CPU: 94% of 32 cores

Note: Majority CPU increase is due to additional work

- System Throughput: 286 TPS

+ 60%

- System Throughput: 460 TPS

3 x 8-core POWER7 partitions
48 GB true, 0 GB expanded

DB + App   AppServer   AppServer   IDLE

4 x 8-core POWER7 partitions
48 GB true, 14 GB expanded

DB + App   AppServer   AppServer   AppServer

IBM PowerVM Hypervisor Is More Efficient Than Competitive Hypervisors

Wasted Resources

11% CPU overhead with 4 VMs

7% CPU overhead with 3 VMs

3% CPU overhead with 2 VMs

% CPU Utilization (32 cores)

31.07
22.8
20.04
15.06
12.806
9.86
5.75
5.22

Legend: Competitor — IBM Power 750

Number of Virtual Servers On the Physical Server

Large Scale Virtualization Is Not Enough, It Also Needs To Be Responsive!

Constant Workload

4070 TPS

tps

Elapsed Time (Minutes)

WebSphere on PowerVM

Immediate and sustained 4070 TPS.

TPS

5 minutes

Competitive Hypervisor

Five minutes to reach maximum 1475 TPS, which could not be sustained.

TPS

225 440 1125 1475

5 minutes
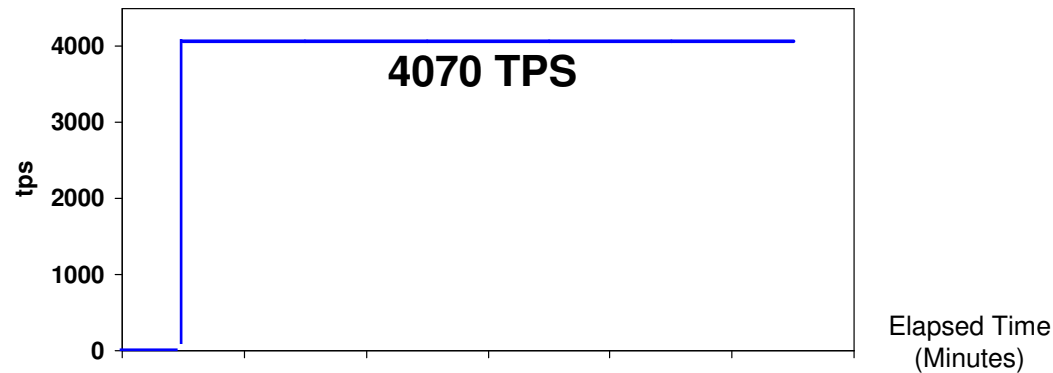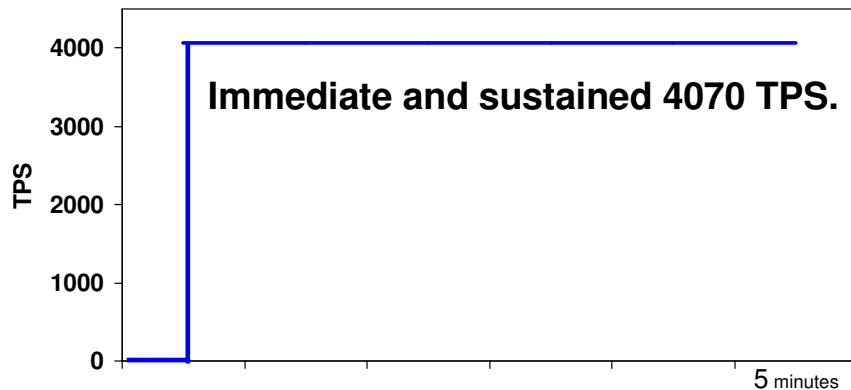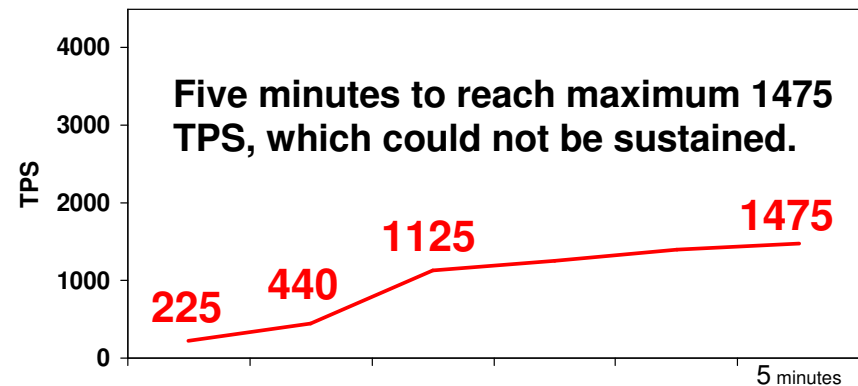
Need to make computing resources available quickly to meet variations

PowerVM vs VMware –
Hardware Hypervisor vs. Software Hypervisor

Wow! PowerVM looks very efficient compared to Oracle VM.

How does it compare to VMware?

Think about Hardware vs Software Hypervisors. Hardware implementations are always faster and scale much better.

Service Oriented Finance CIO

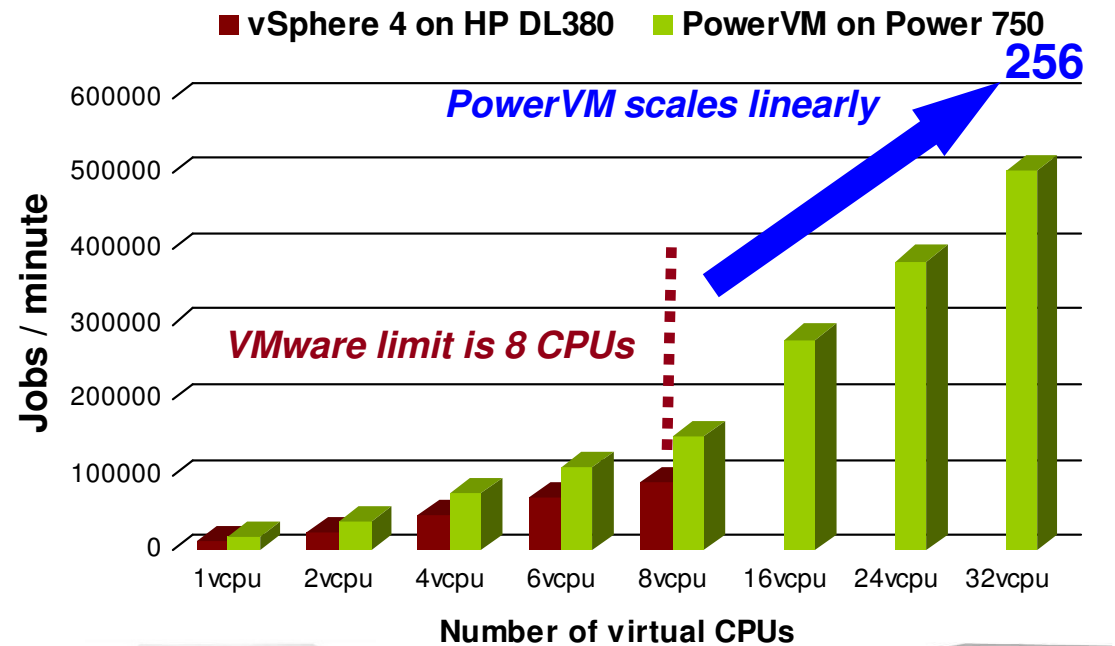**IBM**

PowerVM Scalability – Unmatched!

8 CPU's vs 256 CPU's

65%

PowerVM outperforms VMware by up to 65% on Power 750, **with linear scaling that maximizes resource utilization** with 4x as many virtual CPUs[1]

POWER7 enterprise servers with PowerVM **scale far beyond the limits imposed by x86 architecture and VMware with up to 256 cores in a single Virtual Server**

Performance Benchmark
Single VM Scaling (Scale-up)

■ vSphere 4 on HP DL380   ■ PowerVM on Power 750

PowerVM scales linearly

256

VMware limit is 8 CPUs

Jobs / minute

600000
500000
400000
300000
200000
100000
0

1vcpu 2vcpu 4vcpu 6vcpu 8vcpu 16vcpu 24vcpu 32vcpu

Number of virtual CPUs

HP DL380 G6

Power 750

1 "A Comparison of PowerVM and VMware Virtualization Performance", March 2010

VMware In-Efficiency Is Even Worse Than Oracle VM For SPARC

Virtualized result is 62% of the bare metal result

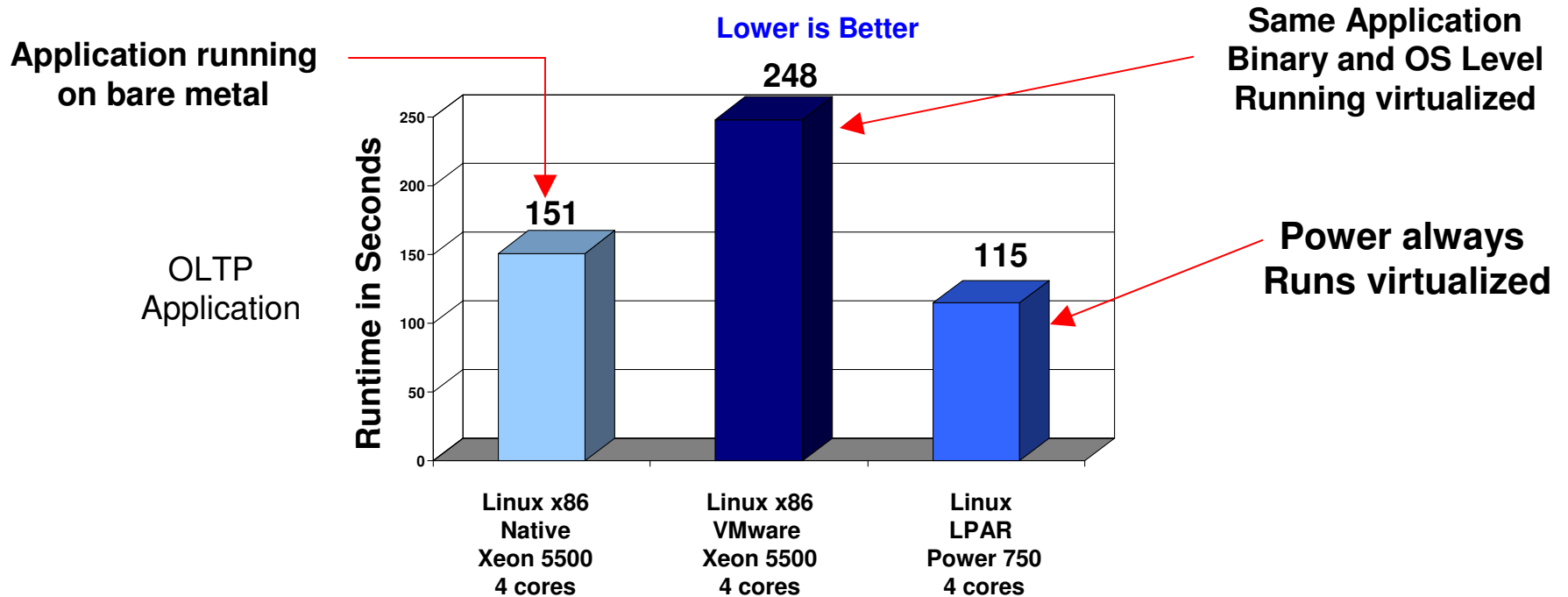| No. of Users	SAPS	System Description	SAPS Per core
3328	18170	Fujitsu PRIMERGY Model TX300 S5 / RX300 S5, 2 Processors / 8 Cores / 16 Threads, Intel Xeon Processor X5570, 2.93 Ghz, 64 KB L1 cache and 256 KB L2 cache per core, 8 MB L3 cache per processor	2271
2056	11230	Fujitsu PRIMERGY Model RX300 S5 / 2 Processors / 8 Cores / 16 Threads, Intel Xeon Processor X5570, 2.93 Ghz, 64 KB L1 cache and 256 KB L2 cache per core, 8 MB L3 cache per processor, **VMware VM**	1404

38%
Overhead!
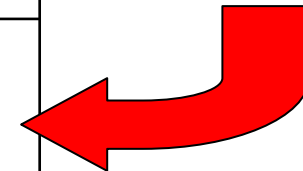
For more information, see "A Comparison of PowerVM and x86-Based Virtualization Performance, available at http://www-03.ibm.com/systems/power/software/virtualization/whitepapers/powervm_x86.html and also: http://www.sap.com/solutions/benchmark/sd2tier.epx

VMware In-Efficiency; Linux Workloads On "Small" Server

VMware causes 40% Overhead when compared to bare metal

Lower is Better

Application running on bare metal

Same Application Binary and OS Level Running virtualized

Power always Runs virtualized

OLTP Application

Runtime in Seconds

248

151

115

Linux x86
Native
Xeon 5500
4 cores

Linux x86
VMware
Xeon 5500
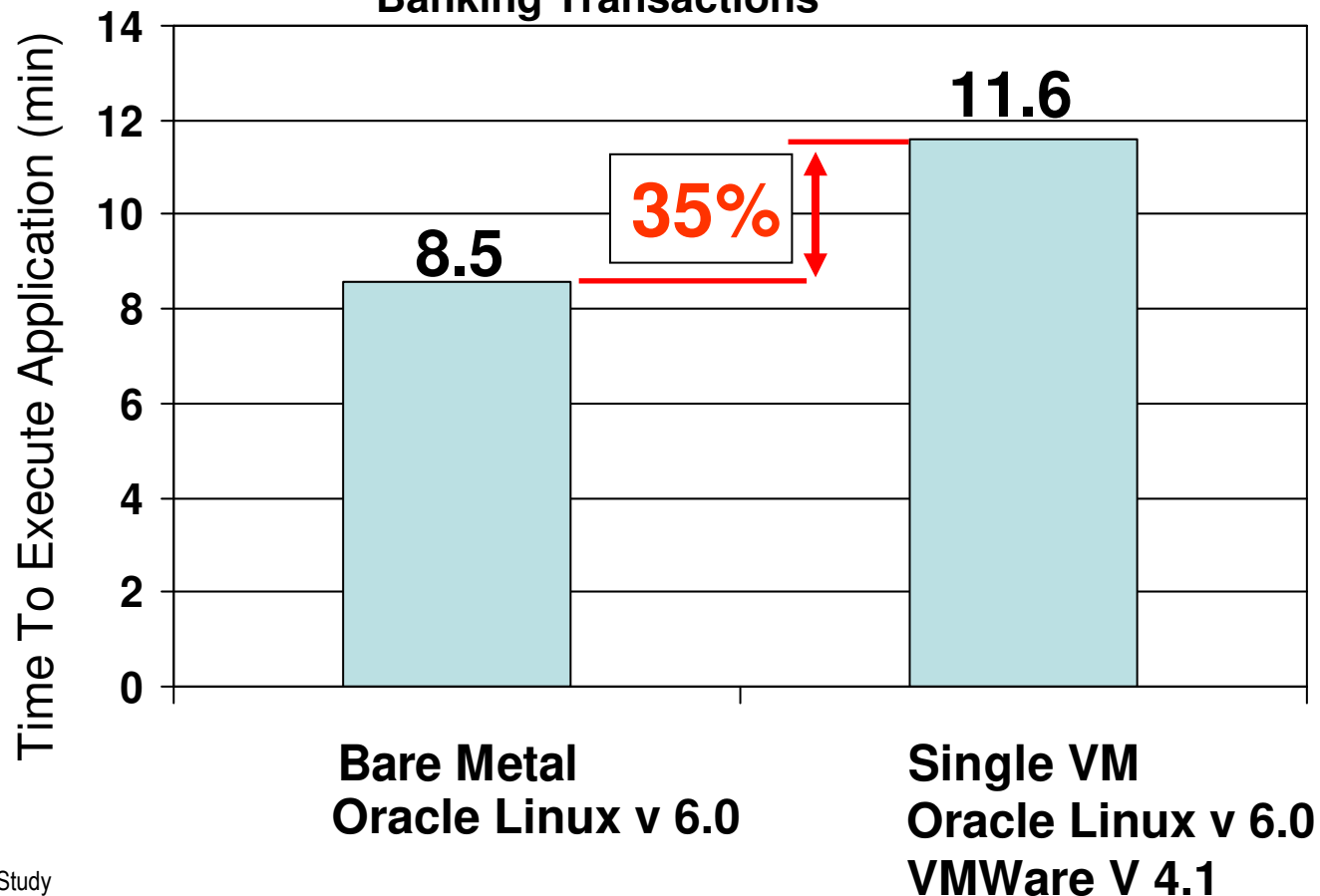4 cores

Linux
LPAR
Power 750
4 cores

Note: Native C++ application compiled with gcc in all environments

VMware In-Efficiency;
Linux Workloads On "Large" Server

VMware causes 35% Overhead when compared to bare metal

OLTP Web Application
Banking Transactions

HP 580 G7
(Xeon 7650)
32 Cores
2.26 GHz
128 GB Memory

Y-axis: Time To Execute Application (min), scale 0 to 14

Bare Metal: 8.5
Single VM: 11.6
35%

Bare Metal
Oracle Linux v 6.0

Single VM
Oracle Linux v 6.0
VMWare V 4.1

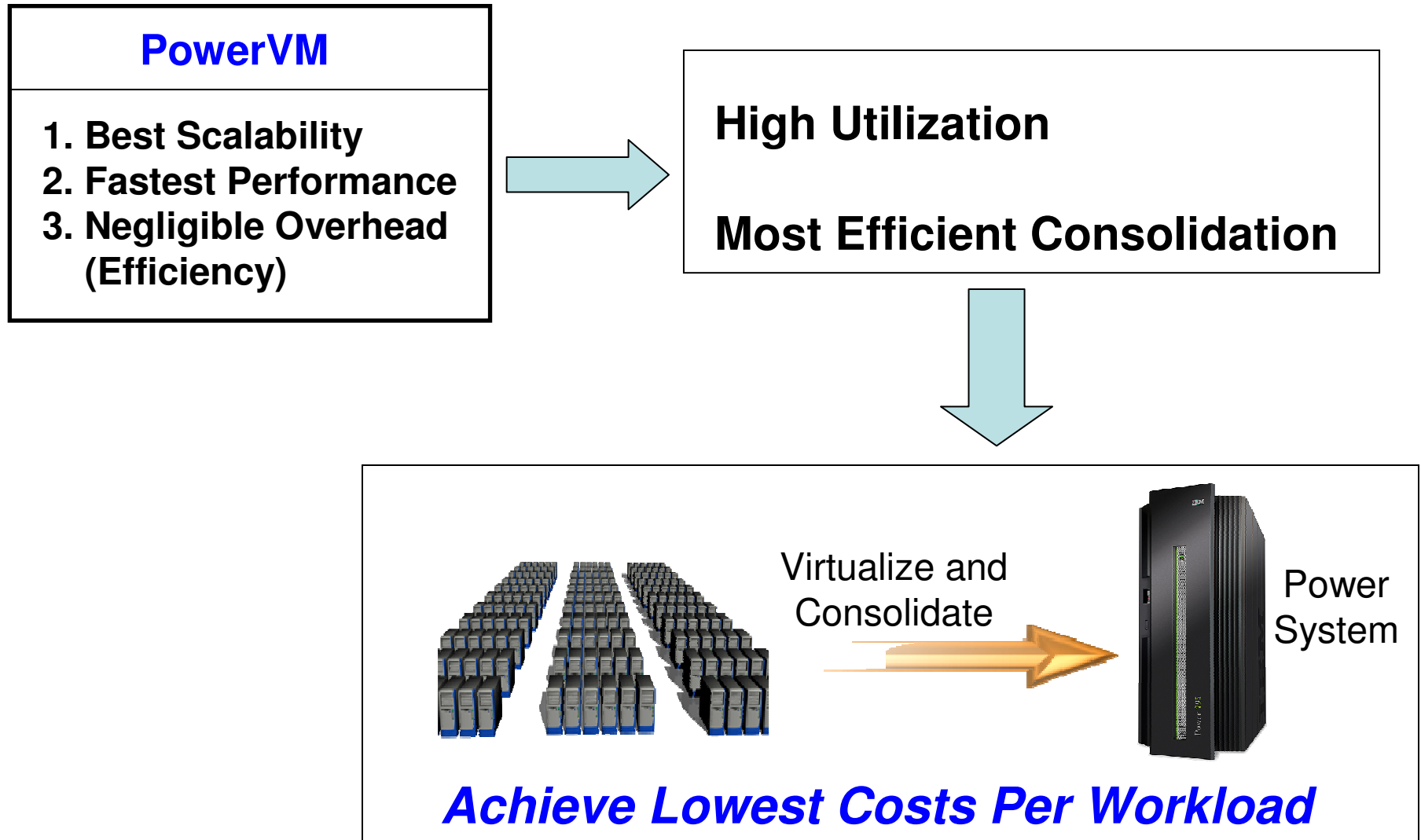# PowerVM Is The Most Secure Hypervisor In The Industry

- Virtualized workloads are isolated from each other
  - ▶ Memory protection keys to guarantee isolation of data in a system
  - ▶ The Power Hypervisor is designed to thwart hacking
  - ▶ EAL 4+ Certified

- Breaches of VMware are posted on the Internet
  - ▶ 2011: http://www.securitytube.net/video/37
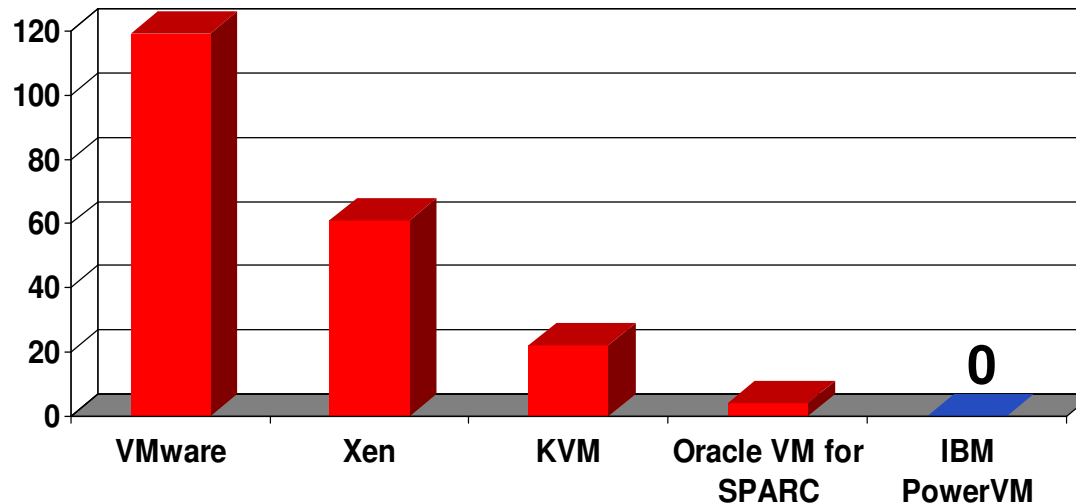
PowerVM has never had a single reported security vulnerability in 10 years

Source: National USA Vulnerability Database: http://nvd.nist.gov/

Why Is It Important For A Hypervisor To Have Scalability, Performance And Efficiency?

PowerVM

1. Best Scalability
2. Fastest Performance
3. Negligible Overhead
   (Efficiency)

High Utilization

Most Efficient Consolidation

Virtualize and Consolidate

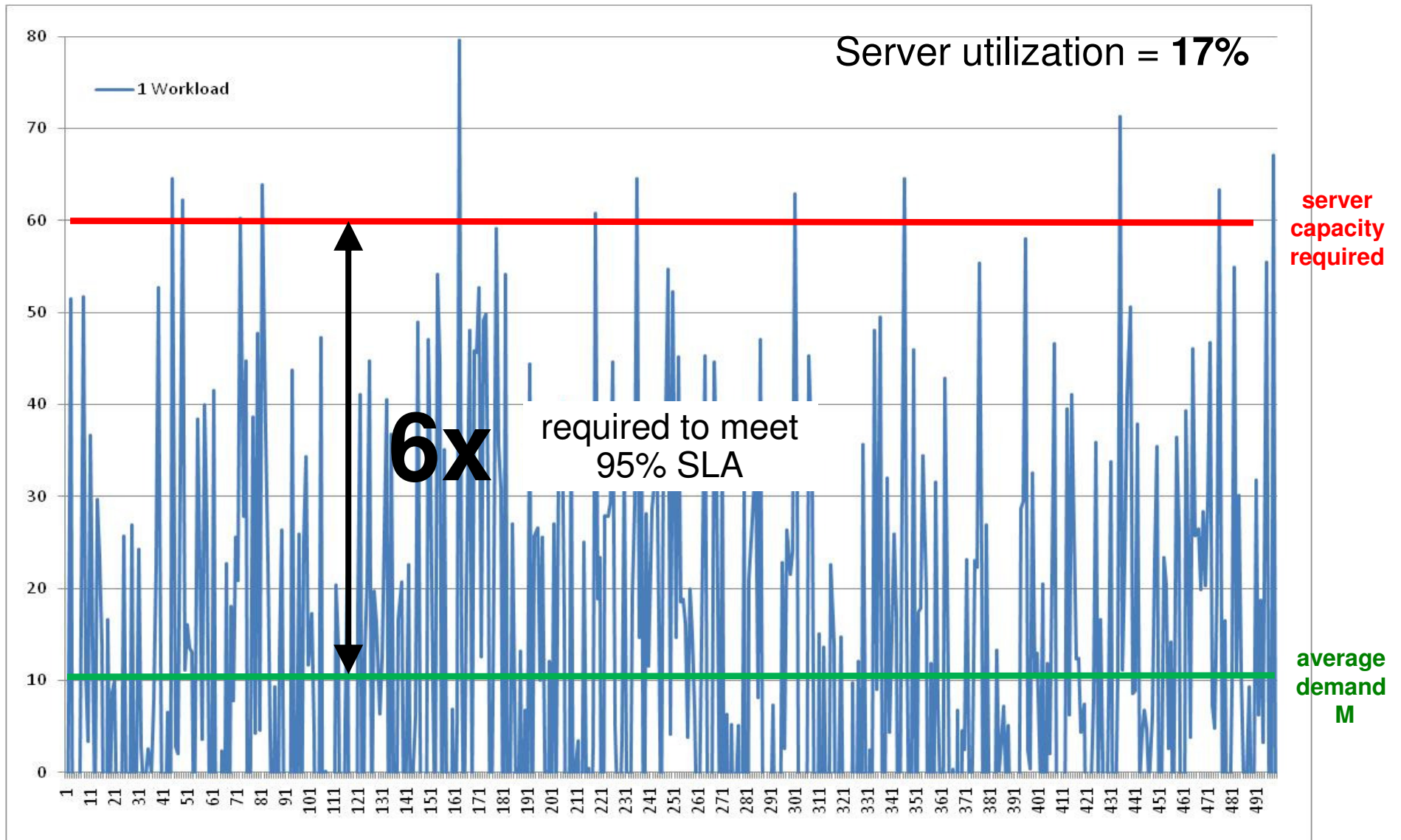Power System

Achieve Lowest Costs Per Workload

Large SMP Systems Make More Effective Virtualization Platforms

- Most workloads experience variability in demand

- When you consolidate workloads with variability on a virtualized server, the variability of the sum is less (statistical multiplexing)

- The more workloads you can consolidate, the smaller is the variability of the sum

- Consequently, big servers with capacity to run lots of workloads can be driven to higher average utilization levels without violating service level agreements, thereby reducing the cost per workload
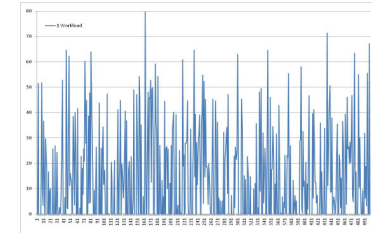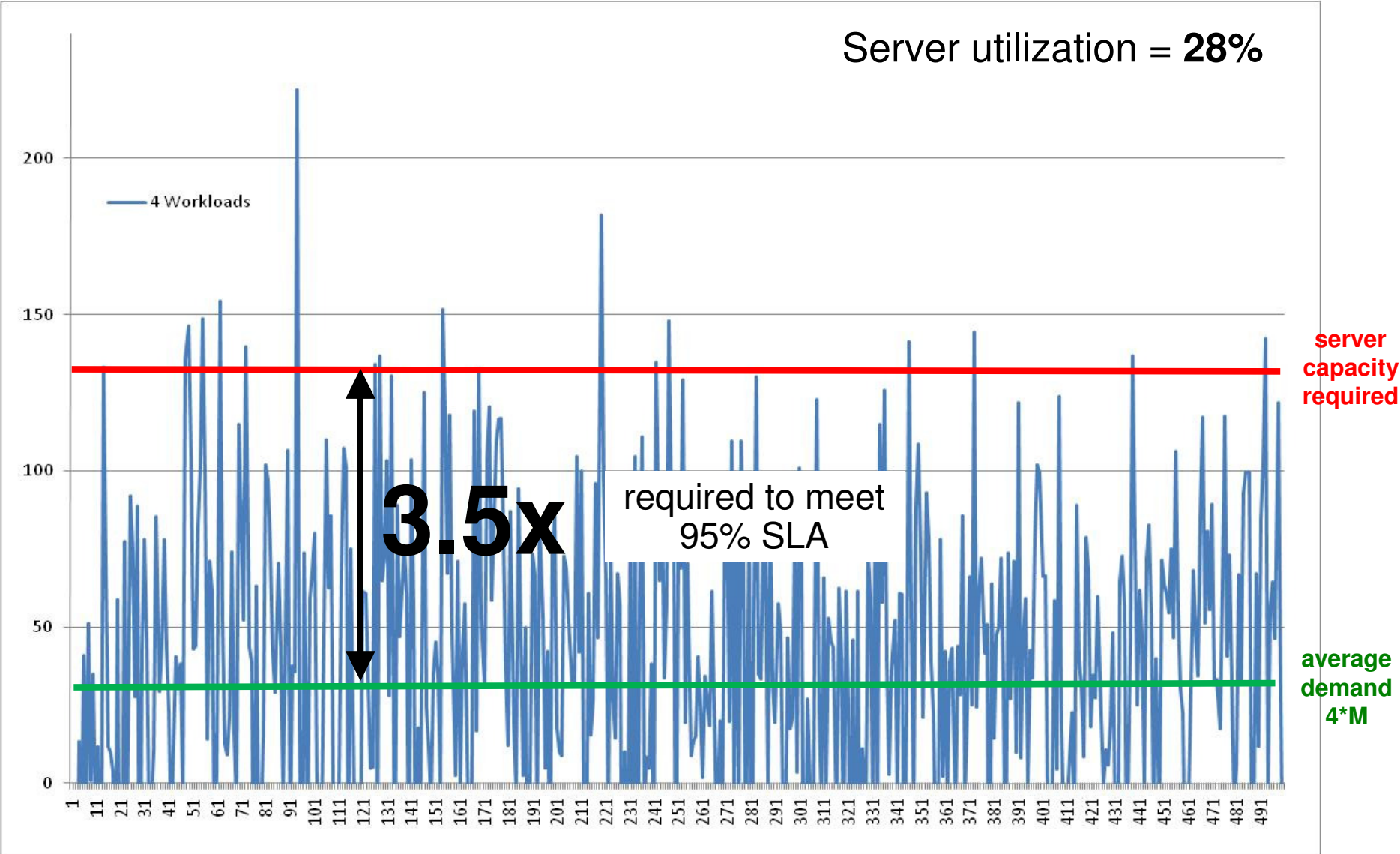
For A Single Workload, We Require A Machine Capacity 6.0x The Average Demand
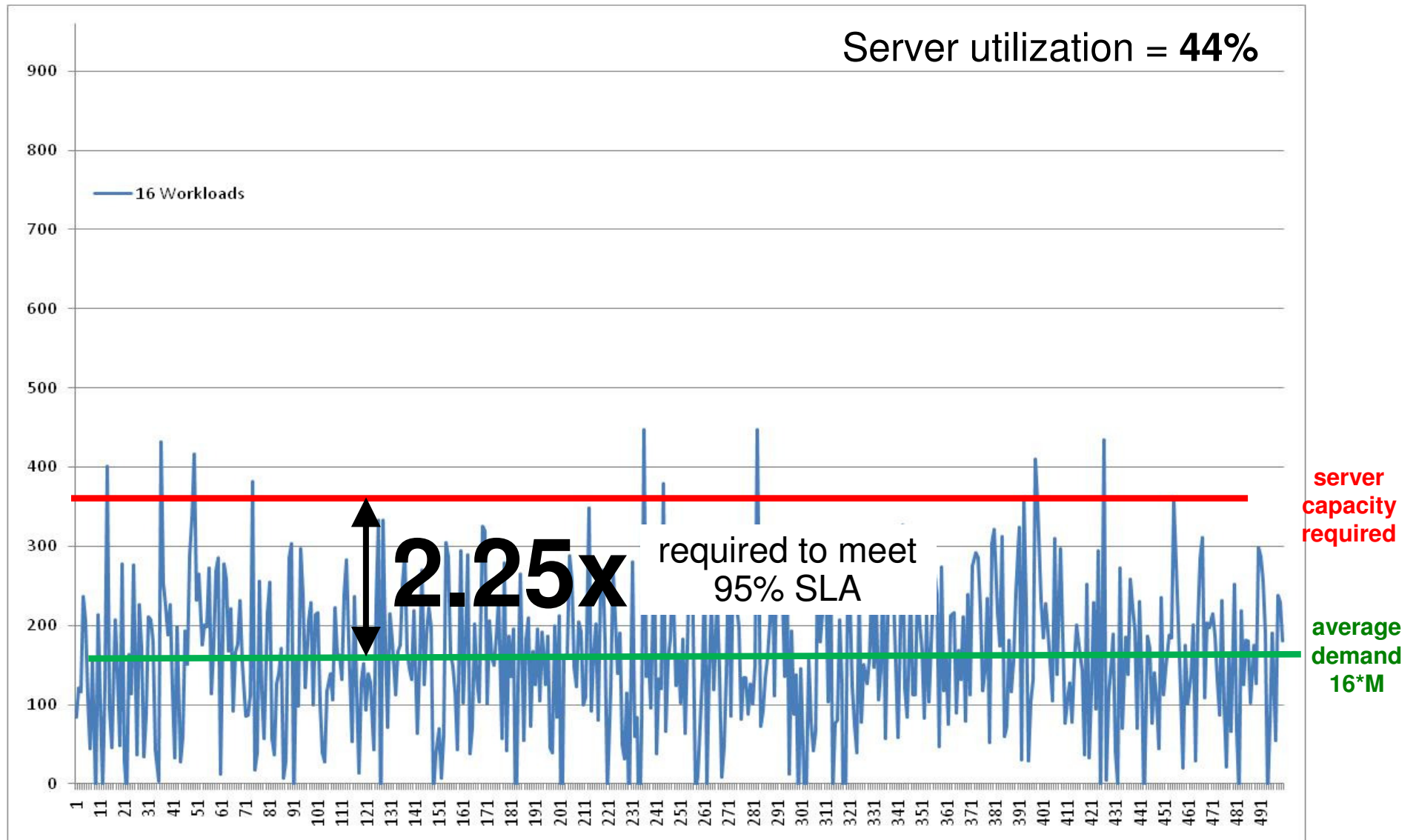

Server utilization = **17%**

1 Workload

6x

required to meet 95% SLA

server capacity required

average demand M

When We Consolidate 4 Workloads We Only Require 3.5x Average Demand

Server utilization = **28%**

3.5x

required to meet 95% SLA

server capacity required

average demand 4*M

When We Consolidate 16 Workloads We Only Require 2.25x Average Demand

Server utilization = **44%**

2.25x required to meet 95% SLA

server capacity required

average demand 16*M

When We Consolidate 144 Workloads We Only Require 1.42x Average Demand

Server utilization = **70%**

144 Workloads

1.42x required to meet 95% SLA

server capacity required
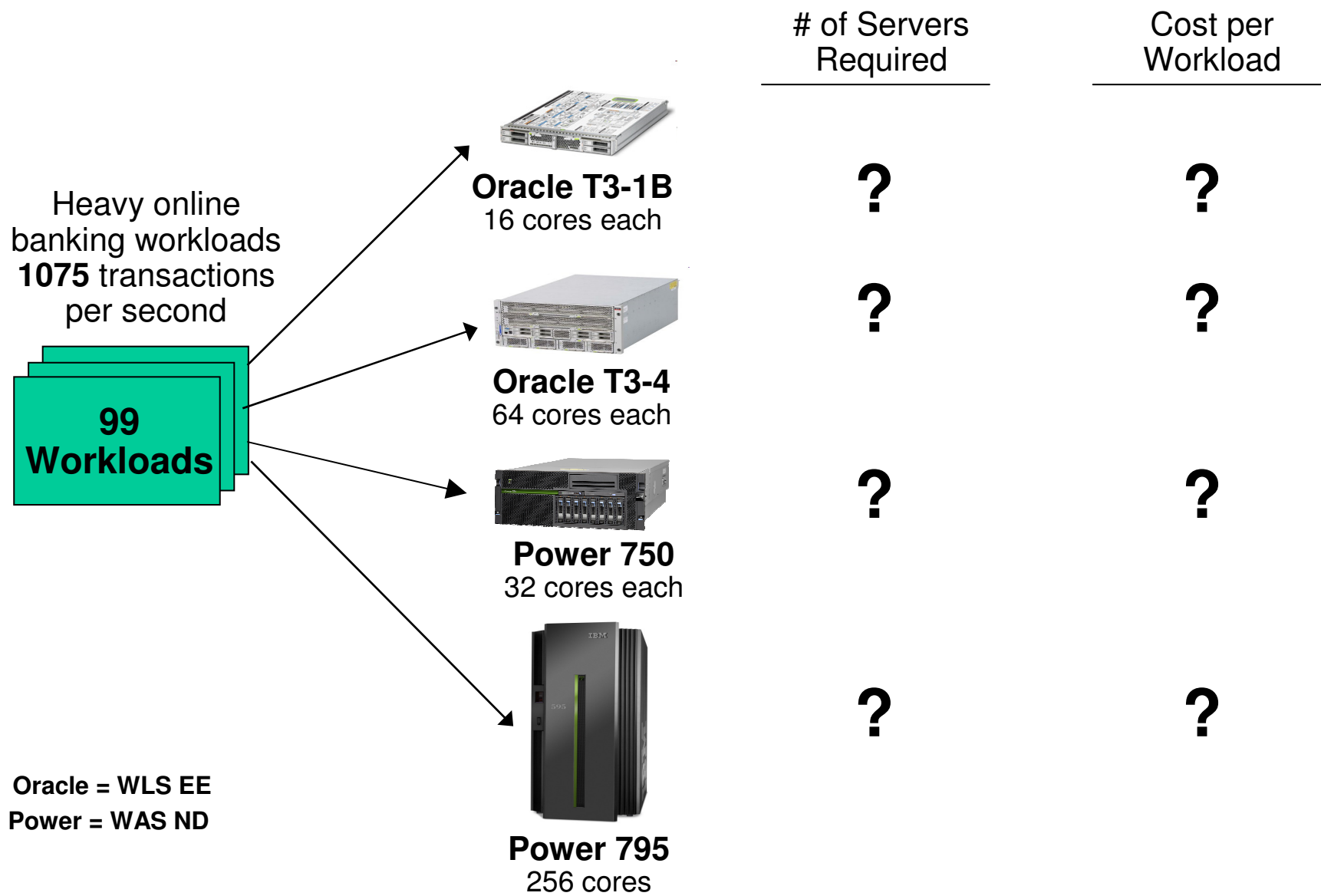
average demand 144* M
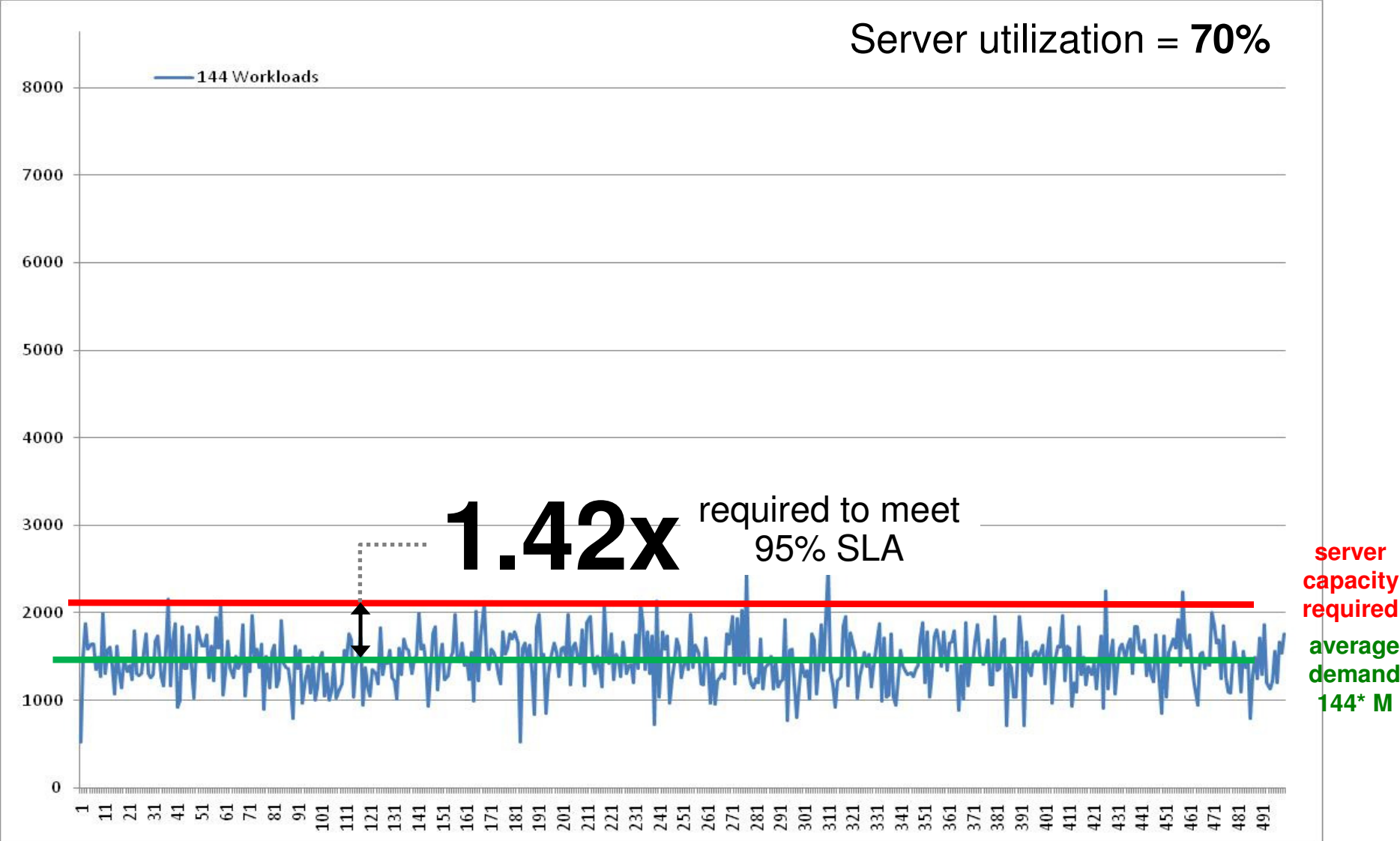
More Workloads For The Same Number Of Cores Results In Lower Cost Per Workload

A single virtualized server with a large pool of shared processors can run more workloads than several smaller servers with the same total number of processors.

Lower Cost per Workload

32 workloads

32 PS 701 Blades
8 cores per shared server
256 POWER7 cores

4x
more workloads
128 workloads

8 Power 750
32 cores per shared server
256 POWER7 cores

8.2x
more workloads
262 workloads

1 Power 795
256 cores per shared server
256 POWER7 cores
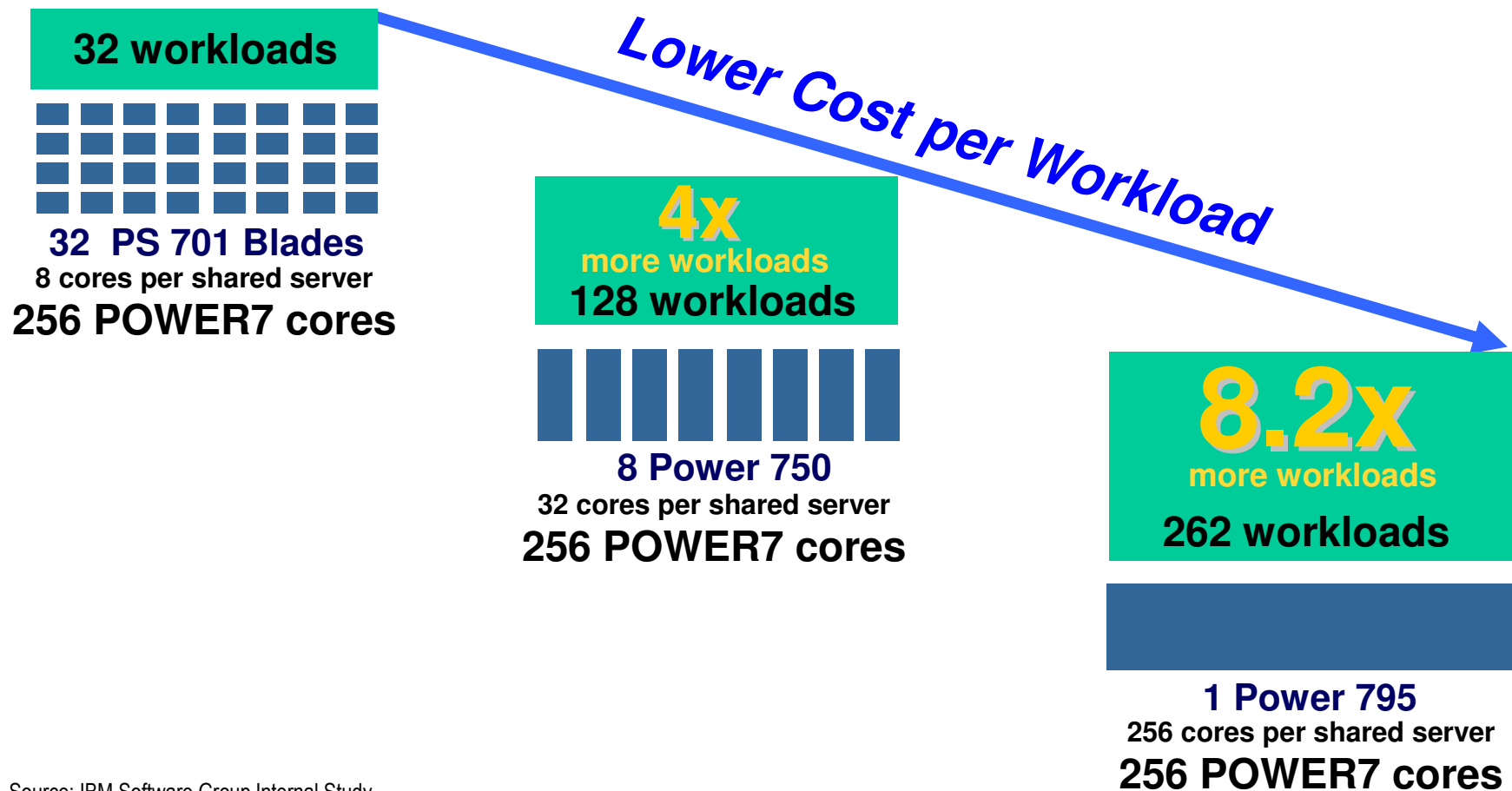
Which Platform Delivers The Lowest Cost For **Large** Workloads?

	# of Servers Required	Cost per Workload
Oracle T3-1B 16 cores each	**?**	**?**
Oracle T3-4 64 cores each	**?**	**?**
Power 750 32 cores each	**?**	**?**
Power 795 256 cores	**?**	**?**

Heavy online banking workloads **1075** transactions per second

99 Workloads

Oracle = WLS EE

Power = WAS ND

Consolidation On IBM Power Systems Also Drives Down Software Licensing Costs Significantly

Total Cost Of Acquisition (TCA)
Cost Per Workload
(Includes HW, SW, 3 Year Support)

74% lower software licensing costs due to a reduction of 1344 cores
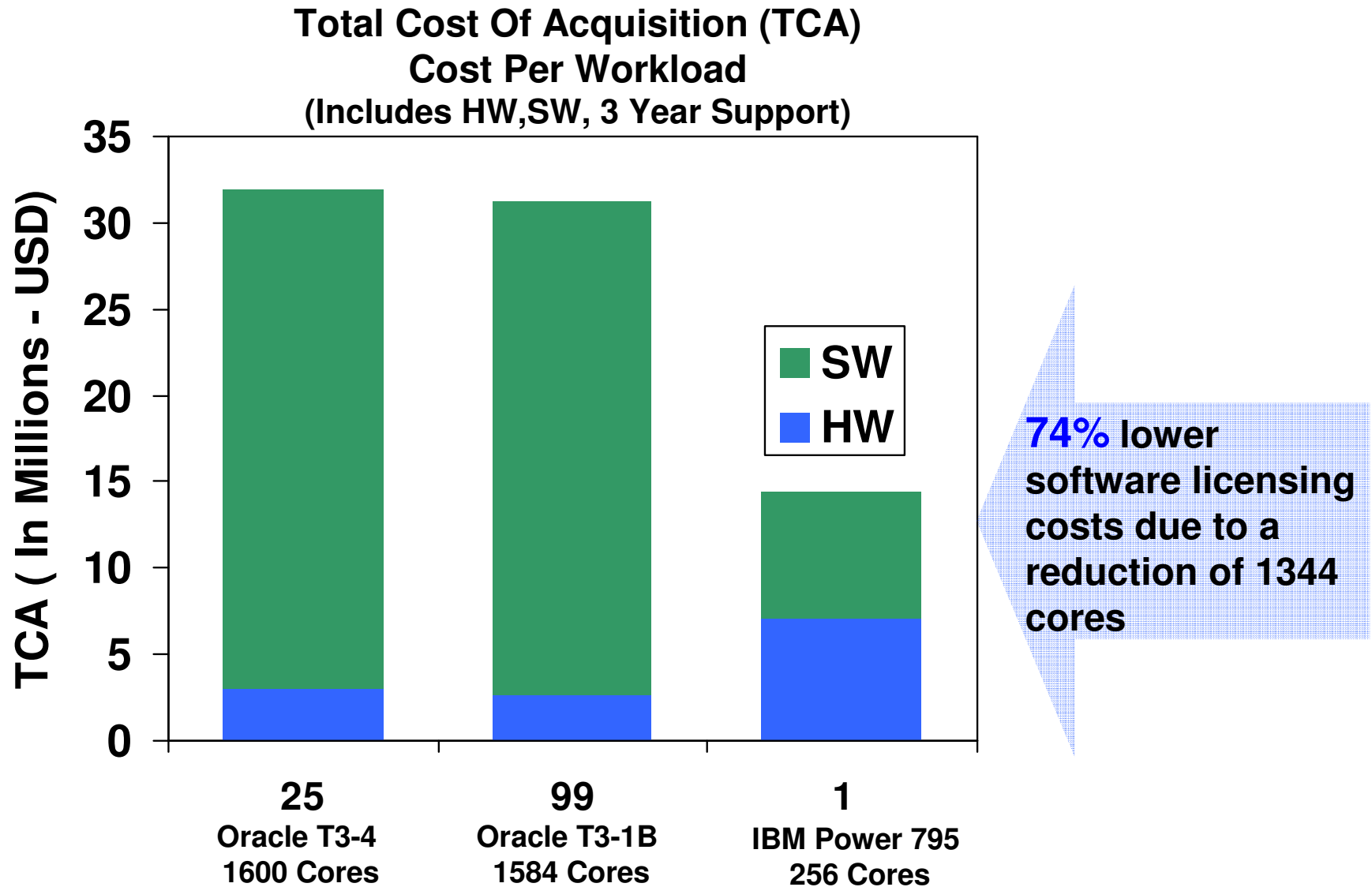
Management and Flexibility Are Very Important In Server Virtualization

PowerVM gives me the lowest cost per workload. Does it help me better deploy and manage these virtualized environments?

Power Systems capabilities help you save money, reduce outages, reduce downtime, and simplify platform management.
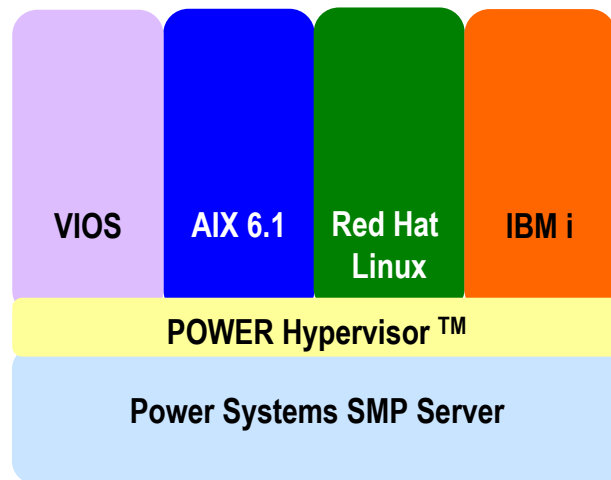Let us see how.

Service Oriented Finance CIO

IBM

Challenges Customers Face When Managing Virtualized Environments
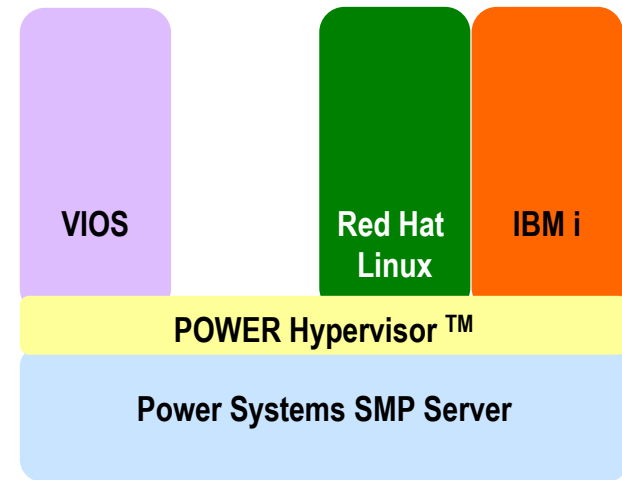
- **Resource balancing**
  - ▶ A system does not have enough resources for the workload while another system does

- **New system deployment**
  - ▶ A workload running on an existing system must be migrated to a new, more powerful one

- **Availability requirements**
  - ▶ When a system requires maintenance, its hosted applications must not be stopped and can be migrated to another system

DEMO: With Live Partition Mobility You Have The Flexibility To Manage Any Adverse Condition

- **Move a LPAR to a different physical server with NO downtime!**
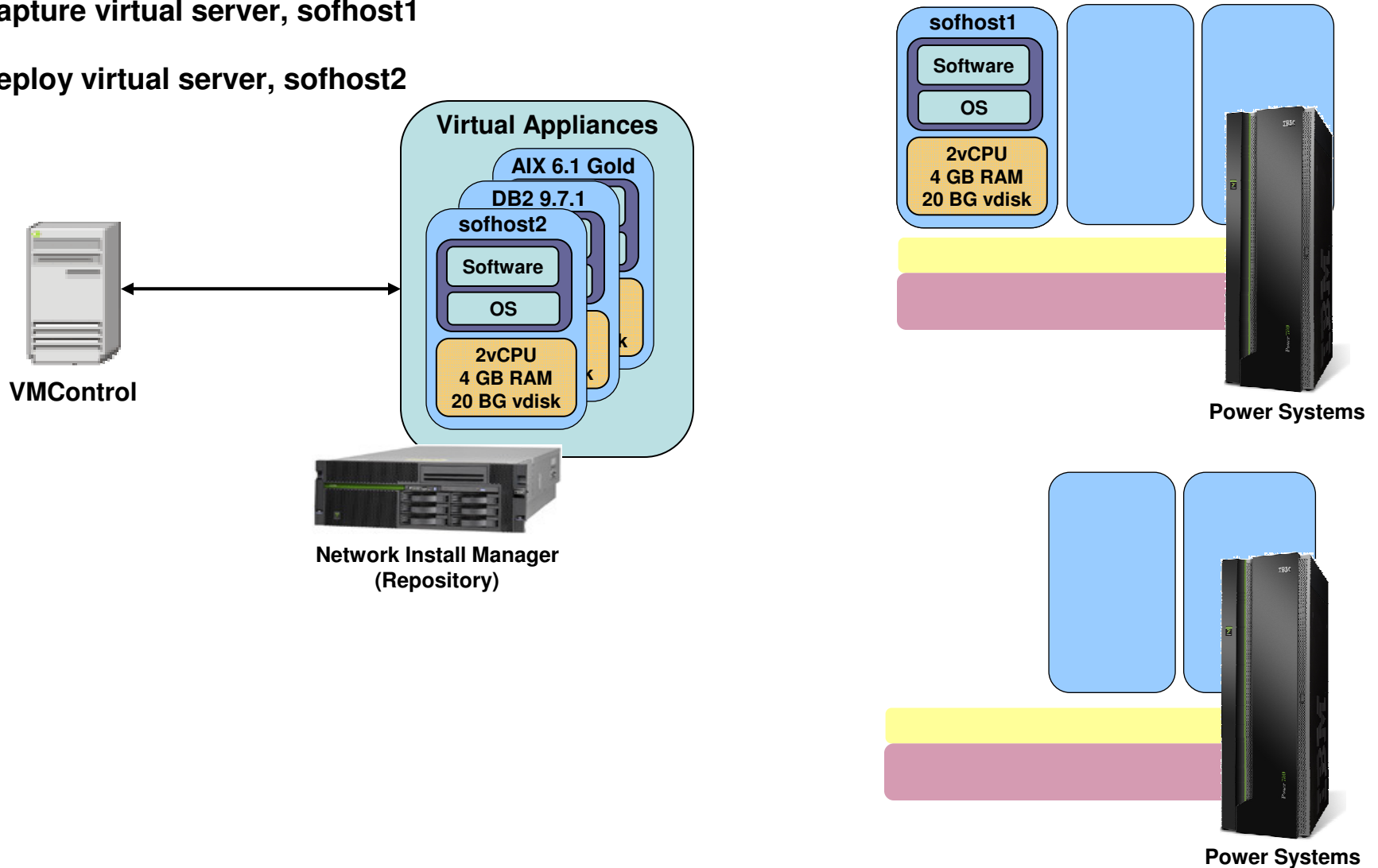- **Transparent to users and applications**

Server 1

| VIOS | AIX 6.1 | Red Hat Linux | IBM i |

POWER Hypervisor ™

Power Systems SMP Server

Server 2

| VIOS | | Red Hat Linux | IBM i |

POWER Hypervisor ™

Power Systems SMP Server

Manage PowerVM And Much More With IBM Systems Director **VMControl**

- **VMControl is a plug-in to IBM Systems Director**

- Manage all IBM platforms, physical and virtual
  - ▶ Power Systems, System z, System x, Storage Systems
  - ▶ Align infrastructure resources with business goals

- Capture inventory of physical and virtualized resources

- Organize resources into System Pools
  - ▶ Simplify management by aggregating physical hosts, storage, and network resources as a single entity
  - ▶ Leverage the statistical multiplexing capabilities of PowerVM to balance workloads and decrease the cost per workload
  - ▶ Increase utilization by using automatic provisioning to scale workload
  - ▶ Increase workload availability by relocating workloads during planned and un-planned outages

- Manage and deploy virtual server images with ease

IBM Systems Director VMControl Simplifies Virtual Server Image Management

1. **Capture virtual server, sofhost1**

2. **Deploy virtual server, sofhost2**

VMControl

Virtual Appliances

AIX 6.1 Gold

DB2 9.7.1

sofhost2

Software

OS

2vCPU
4 GB RAM
20 BG vdisk

**Network Install Manager
(Repository)**

sofhost1

Software

OS

2vCPU
4 GB RAM
20 BG vdisk

Power Systems

Power Systems

DEMO: Use IBM Systems Director With VMControl For Virtual Server Image Management

Can clone any partition (LPAR)

- Deploy virtual machine from image repository

IBM Factories Get You Started On The Road To Consolidation

- Free Proof of Concept and cost/benefit analysis

- Includes high level architecture

- Consolidation Discovery and Analysis Tool (CDAT) now available as a free download for IBM Sales and Business Partners

> Our teams conduct data center interviews and run analysis tools to assess current efficiency and make consolidation recommendations.

IBM

- **Server Consolidation Factory**
- **x86 Server Consolidation Factory on POWER Systems**
- **Availability Factory**
- **Migration Factory**

http://www-03.ibm.com/systems/migratetoibm/factory/

Summary: Consolidate Diverse Workloads On Power Systems And Save $$

- PowerVM achieves the **lowest total cost** per workload

- Unmatched **Statistical Multiplexing** capability and large-scale server virtualization allows massive consolidation

Virtualize and Consolidate → Power System

Achieve Lowest Costs Per Workload
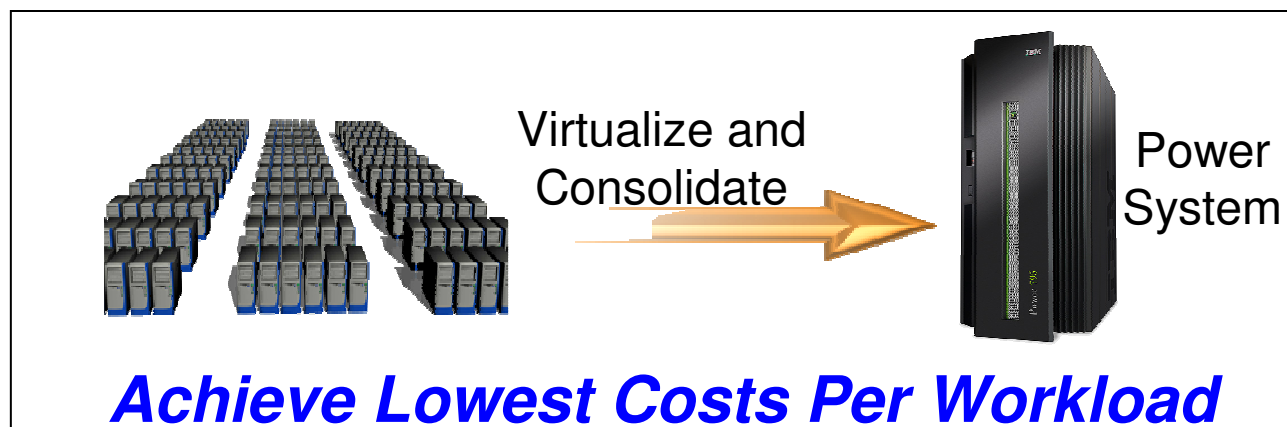
- **Secure** virtualization on Power Systems reduces risk and enables a bullet-proof environment

- **Virtualization management** on Power Systems allows for a dynamic infrastructure for private cloud computing