Campus Days
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Windows Server 2008 R2 - Best Practices og Performance Tooling

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Windows Server 2008 **R2**

Microsoft *TechNet*

Agenda

- Overview
  - New Hardware Support
  - New Performance Features
  - Performance Improvements
- Selected Deep Dive
  - What changed?
  - How?
  - Results?
- Questions and Answers

Windows Server 2008 R2

In a Nutshell…

- R2 is more than a "patch" or "service pack"
- The most scalable release of Server
- Performance gains in a number of areas
- New features to address pain points
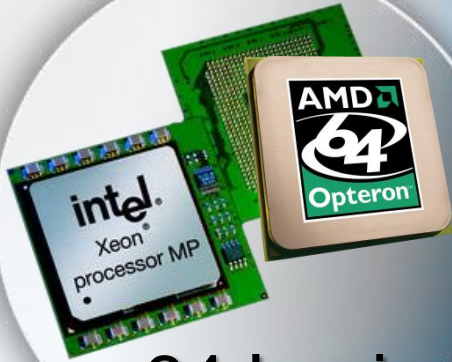- Great today, ready for tomorrow

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Hardware Inflection Points

Multi-core

Virtualization

> 64 Logical Processors

Power

Overview
New Hardware Support

- CPUs
    - \> 64 Logical Processors (LP)
    - Power
        - Improved C State Support
        - Support for Core Parking
- Virtualization
    - Hardware SLAT (EPT/NPT)

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Overview
New Features – Part 1 of 2

- ~~32bit~~

- \> 64LP enlightenments
  - Network stack, storage stack, tools
- Cooperative Scheduling
  - User Mode Scheduling (UMS)
- NUMA enhancements
  - Topology APIs
  - NUMA-aware RSS

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Overview
New Features – Part 2 of 2

- Hot Lock "removal"
  - Scheduler Dispatcher
  - Memory Manager PFN
  - Cache Manager VACB
  - Object Type

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Overview
Improvements - Part 1 of 3

- Virtualization
  - 64 LP!
  - Scalability Improvements
  - NUMA Scheduling
  - Dynamic VHDs
- Boot Optimizations
  - Device initialization parallelization
- Power
  - Processor Power Management Policies
  - Timer Coalescing and Tick Skipping

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Overview
Improvements - Part 2 of 3

- Minimization Work
  - Re-factored DLLs
  - Trigger start of Drivers and Services
  - Memory, disk and CPU optimizations
- File Server
  - Improvements in the WAN scenario by reducing network round trips
  - Scalability improvements

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Overview
## *Improvements - Part 3 of 3*

- Storage
  - Clustered Shared Volumes (Centipede)
  - Native VHD
  - NUMA I/O
- Terminal Server
  - Dynamic Fair Share Scheduling (DFSS)
  - Video Performance
  - WAN bandwidth reductions

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Details – > 64 LP

- What changed?
  - R2 supports 256 LPs
- How?
  - Groups
  - Static set of 1 to 64 LPs
  - Determined at boot time
  - Minimal number of groups
  - LP spatial locality important
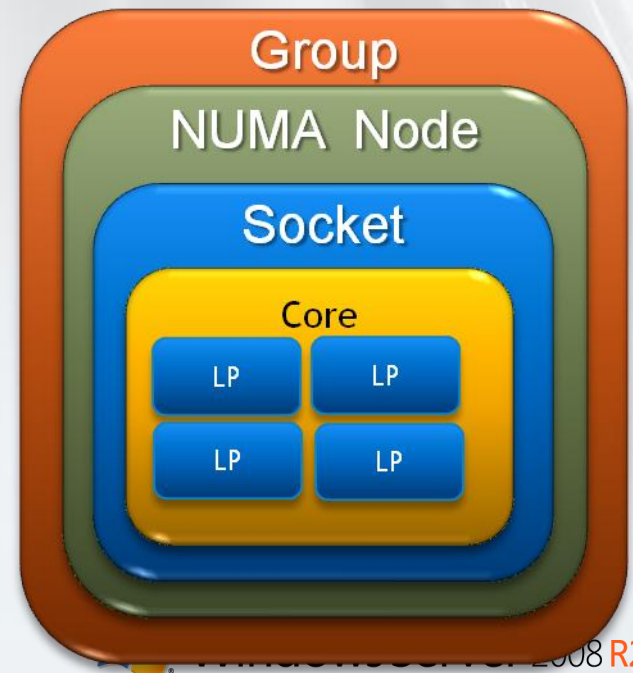
Details – > 64 LPs
An example - 2 Group, 128LPs

Details – > 64 LPs

- Results?
  - Processes assigned round-robin to groups
    - Can be overridden to inherit parent process group
  - Threads inherit group affinity
    - Thread can be affinitized to only a single group
  - Most applications not affected
    - For "Legacy" APIs, group is implied
    - "Legacy" drivers are Group 0
    - New APIs to expose group information
    - Applications that use or store per-processor information for the entire system must be modified

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Details – > 64 LPs
Code Impacts – Minimized

```
#define MAXIMUM_PROC_PER_GROUP    64
#define MAXIMUM_PROCESSORS
          MAXIMUM_PROC_PER_GROUP

// Examples of new APIs
GetMaxiumProcssorGroupCount(…)
GetMaxiumProcssorCount(…)

CreateRemoteThreadEx(…)

GetActiveProcessorGroupCount(…)
GetCurrentProcessorNumberEx(…)
GetLogicalProcessorInformationEx(…)
GetMaxiumProcessorCount(…)

// and many more…
```

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SQL on 256 LPs
video

Details – Lock "Removal"
Terminology

- ## What's a lock
    - A spinlock is a locking primitive associate with global data structures - prevents multiple threads from simultaneously modifying important data
    - Waiting threads "spin" doing nothing waiting for access to the lock
- ## Contention
    - Threads being stalled waiting for their turn to access a lock

Details – Lock "Removal"
Details

- What's changed?
  - Four key Kernel locks have been "removed"
    - Scheduler Dispatcher, Memory Manager PFN, Cache Manger VACB, and Object Manager Type
- How?
  - Decomposition into "smaller" locks
- Results?
  - Less contention, less waiting ⇨ better scalability
  - No detectable change for user applications

Details – Lock "Removal"
Scaling without the Dispatcher Lock

- 1.7x scaling going from 64 to 128 LPs
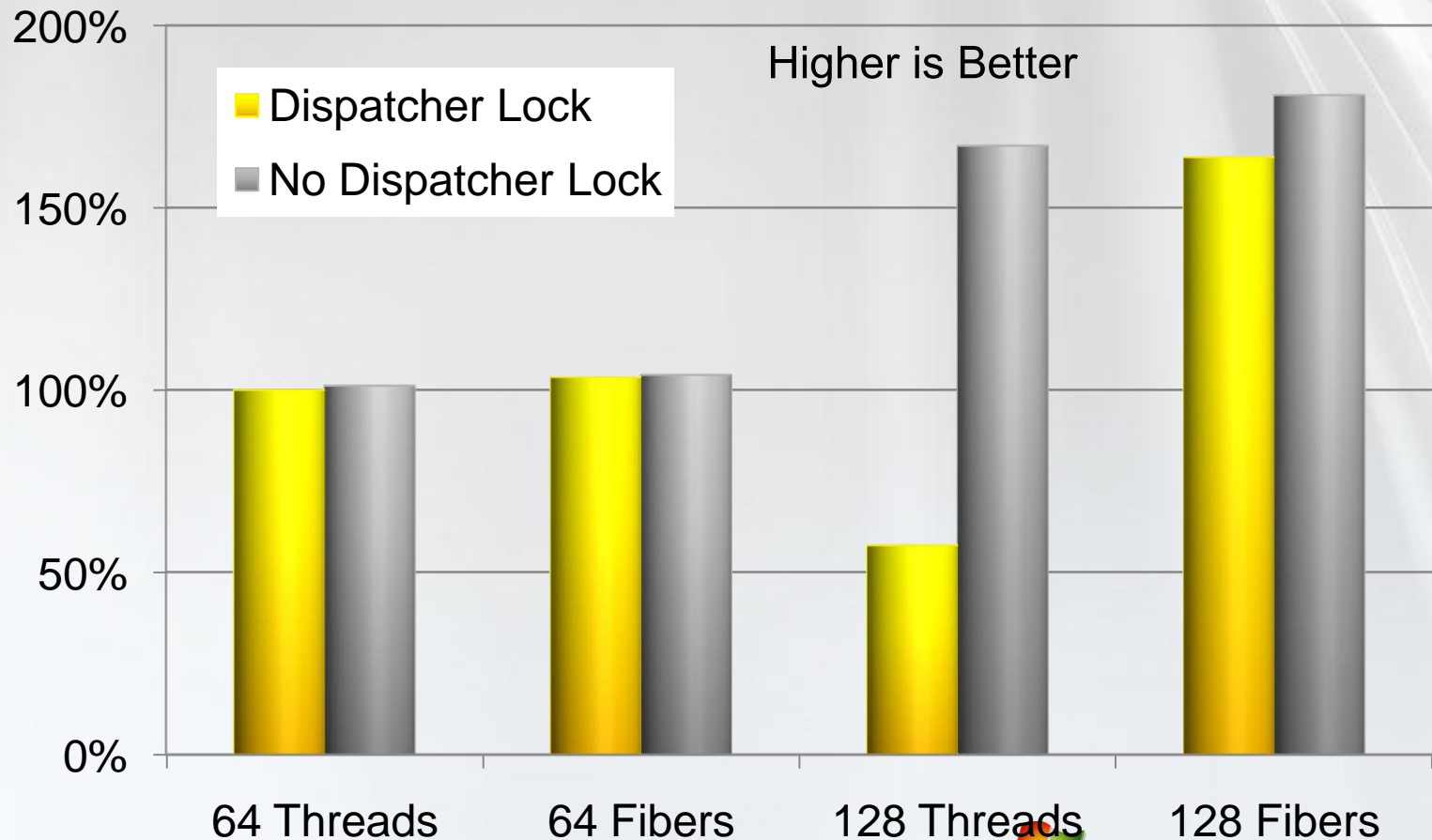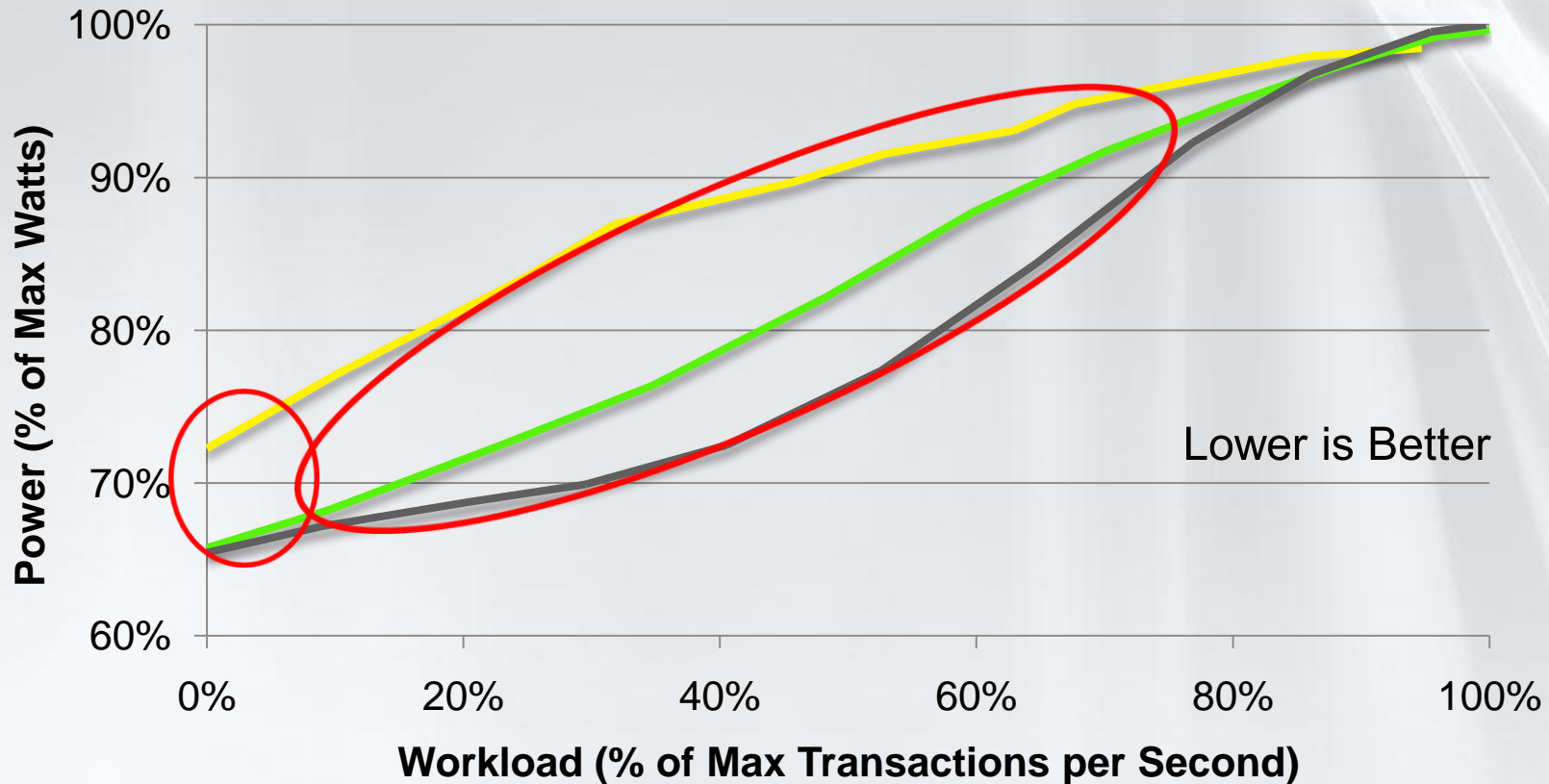
Details – Power Savings

- What changed?
  - Processor Power Management algorithms & settings
  - Increased processor idle state usage
  - Intelligent Tick Distribution, Tick Skipping, Timer Coalescing, and Core Parking
  - New metering and budgeting features
- How?
  - Lots of tuning on diverse workloads (with Intel/AMD assistance and validation)
  - Refactoring of the OS & kernel to minimize idle activity
  - Support for onboard metering
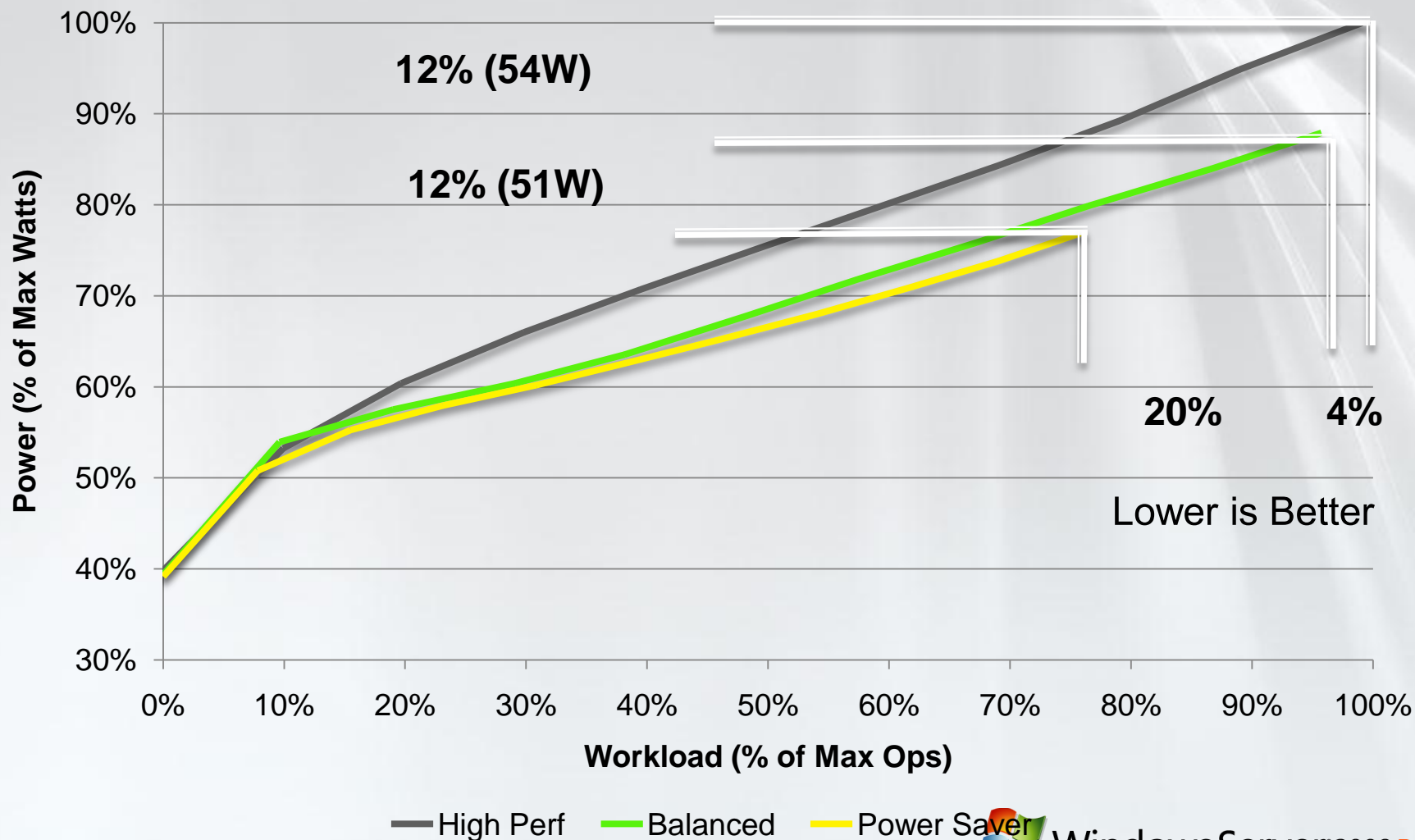- Results?
  - WS08R2 improves greatly from W2k3

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Details – Power Saving
OS Comparison – Out of the Box Settings

Lower is Better

Power (% of Max Watts) vs **Workload (% of Max Transactions per Second)**

— WS2k3 SP2 - High Perf   — WS08 RTM - Balanced   — WS08 R2 RC - Balanced

Details – Power Saving

Power vs. Performance – R2 Power Plans

- **12% (54W)**
- **12% (51W)**
- **20%**
- **4%**

Lower is Better

Power (% of Max Watts)

Workload (% of Max Ops)

— High Perf — Balanced — Power Saver

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Details – Power Saving
Balanced vs. High Performance

Core parking

Demo

Details – Virtualization
Hyper-V Power

Chart: Power (% of Max Watts) vs. SPECpower Workload (% of Max ssj_ops). Lines: W2K8, WS08R2 RC. "Lower is Better"

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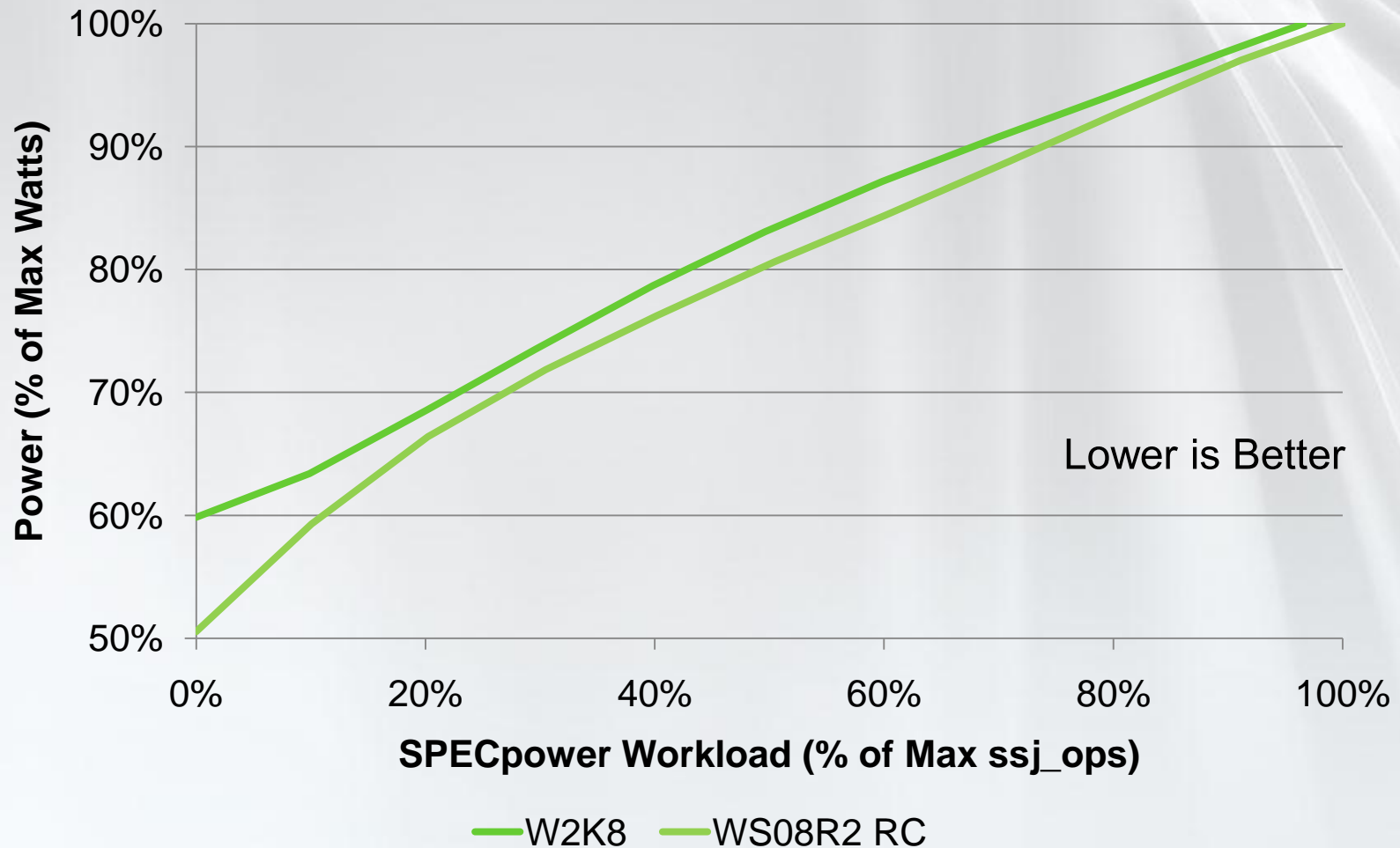
Details – Virtualization
Scalability

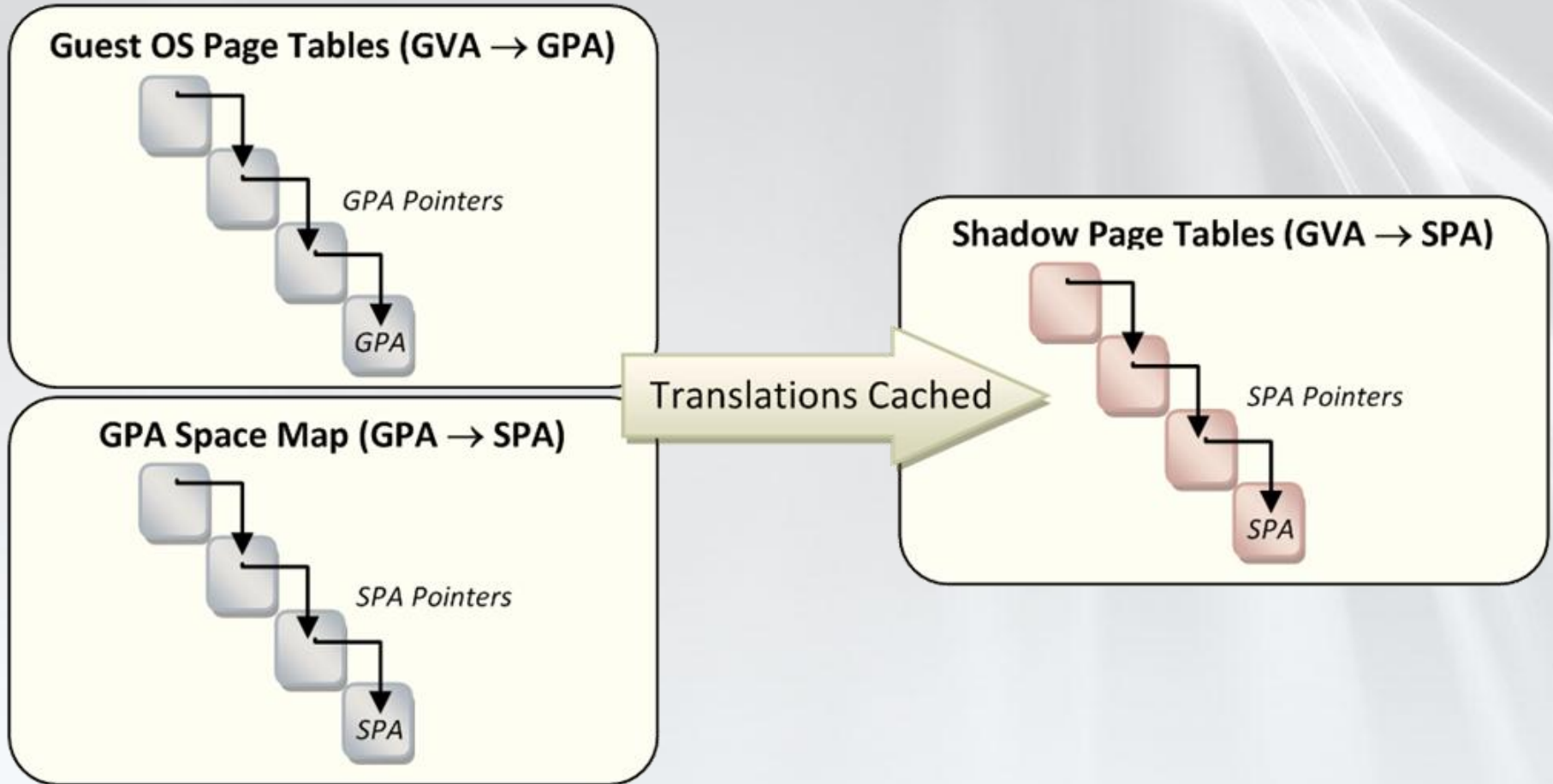| Category	WS08 (v1)	WS08 R2 (v2)
Max LP	24	**64**
VP:LP	4:1	**8:1**
Max Active VMs	96	**384**
Max VPs per VM	4	4
Max VPs	96	**512**
Max Mem per VM	64GB	64GB
Max Mem (Host)	1TB	1TB

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Details – Virtualization
Memory Mapping – Terminology

- Memory Management Units (MMU)
- Guest Virtual Address (GVA)
- Guest Physical Address (GPA)
- System Physical Address (SPA)

- Optimization – Shadow Page Tables

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Details – Virtualization
Shadow Page Tables

Guest OS Page Tables (GVA → GPA)

GPA Pointers

GPA

GPA Space Map (GPA → SPA)

SPA Pointers

SPA

Translations Cached

Shadow Page Tables (GVA → SPA)

SPA Pointers

SPA

Details – Virtualization
Hardware SLAT

- What's new?
  - Shadow Page Tables stored in hardware
  - Second Level Address Translation (SLAT)
- How?
  - Support for hardware SLAT
  - Replaces Multiple Shadow Address Space (MSAS)
  - EPT on Intel, NPT on AMD
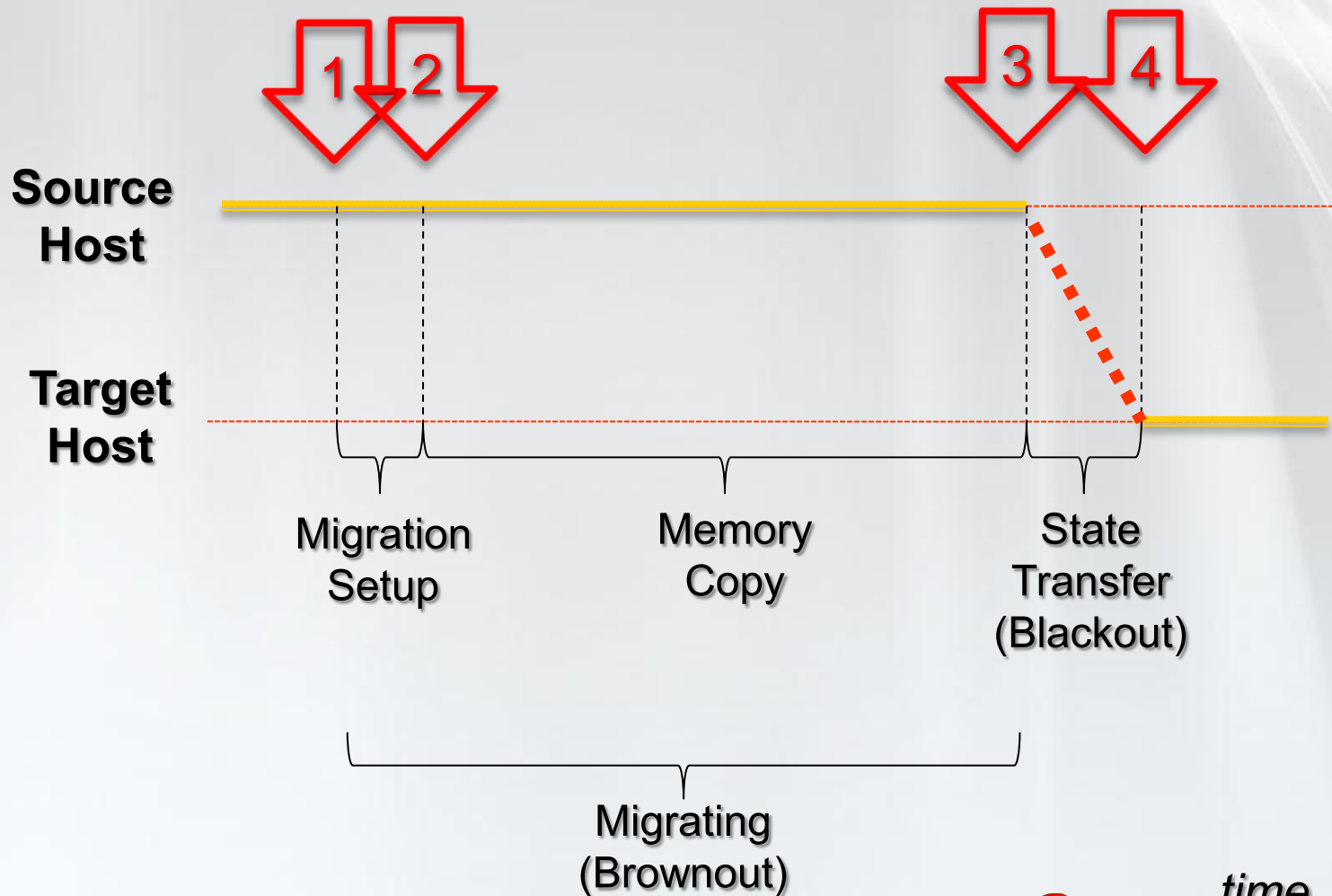- Results?
  - Same performance with less overheard

Details – Virtualization
Live Migration

- What's new?
  - VM moving between Hosts without noticeable interruption
- How?
  - Incremental copy and restore of VM
    - Quick Migration without the downtime
  - Clustered Shared Volumes (Centipede)
    - Required SAN for seamless VM movement between clusters

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Details – Virtualization
Live Migration

Details – Virtualization
Live Migration

- Results?
  - Improved Reliability
    - Load balancing across VM Hosts
  - Migration times can be longer than Quick Migration
  - Down times are very short
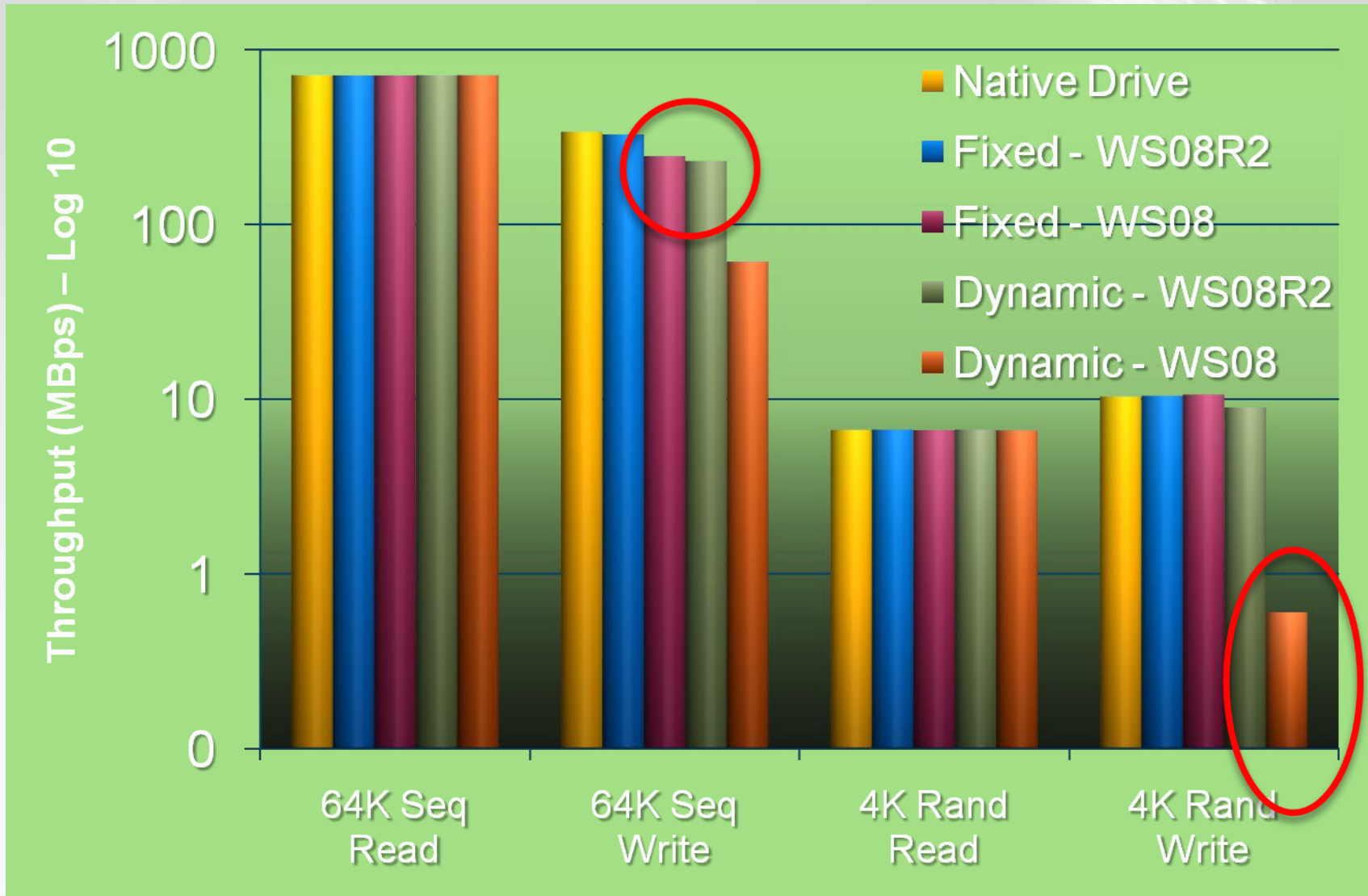
Details – Virtualization
Virtual Hard Drivers (VHD)

- What's changed?
  - A number of performance improvements
- How?
  - Rewritten VHD stack
- Results?
  - Random Write much improved
  - Over all considerably closer to native

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Details – Virtualization
Virtual Hard Drivers (VHD)

Higher is Better
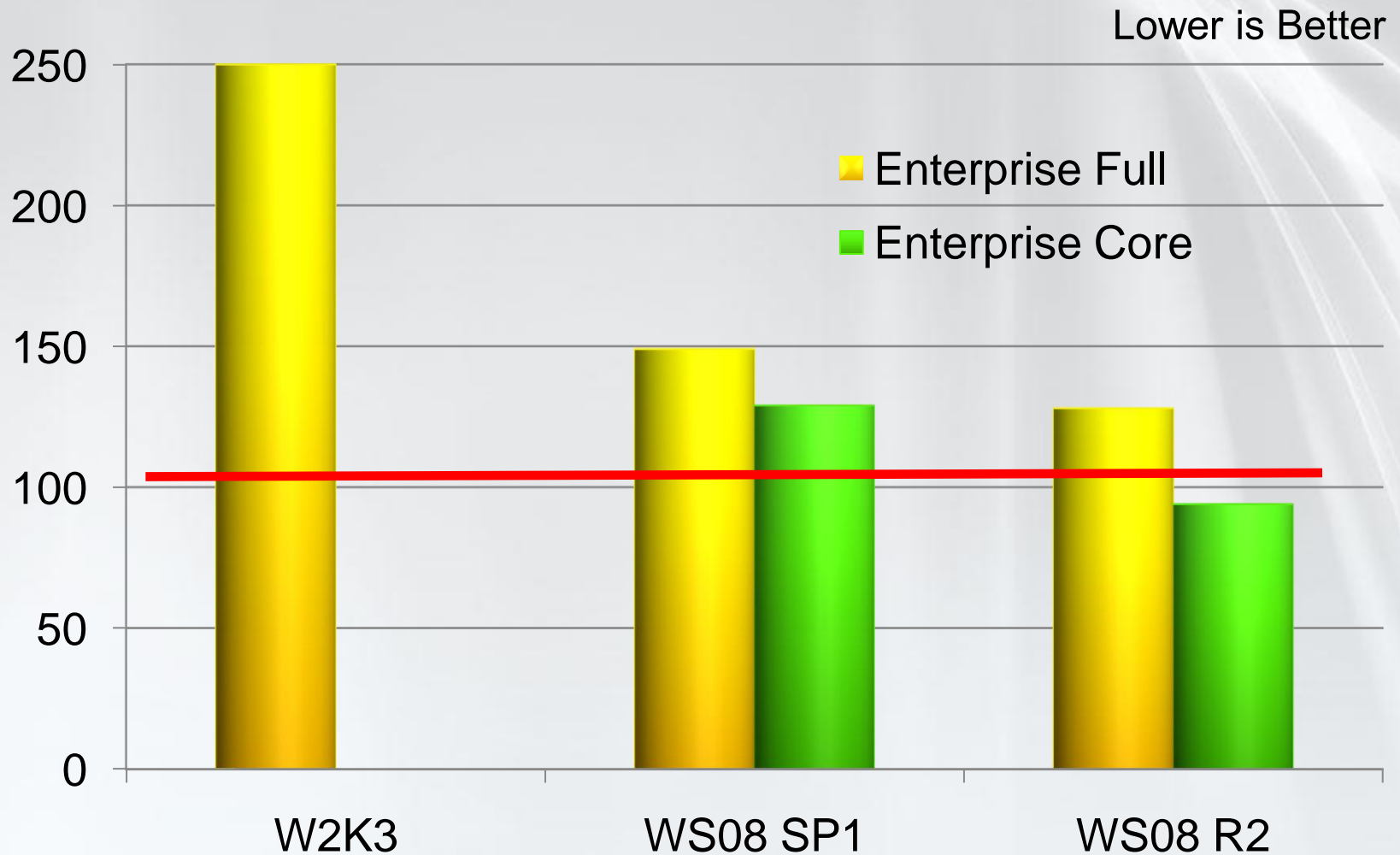
Details – Footprint
Terminology

- Memory Working Set
  - The amount of RAM the memory manager assigns to process or kernel memory type
  - Shown in Task Manager
- Memory Reference Set
  - The amount of Working Set that is actively used by a process or the kernel
- Paged Pool
- Non-paged Pool

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Details – Footprint

- What changed?
  - Memory usage
  - Disks usage
- How?
  - Demand start of Drivers and Services (UBPM)
  - Memory Manager changes
  - Targeted testing and analysis of usage
- Results
  - Memory
    - Better utilization
    - Smaller Reference Set
    - Reduced Non-paged pool memory usage
  - Enterprise Full installation is now 2GB smaller on disk

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Details – Footprint

Lower is Better

Legend:
- 🟨 Enterprise Full
- 🟩 Enterprise Core

Chart showing footprint comparison (Lower is Better):
- W2K3: Enterprise Full ≈ 250
- WS08 SP1: Enterprise Full ≈ 150, Enterprise Core ≈ 130
- WS08 R2: Enterprise Full ≈ 128, Enterprise Core ≈ 95

Red reference line at approximately 105.

Y-axis: 0, 50, 100, 150, 200, 250
X-axis: W2K3, WS08 SP1, WS08 R2

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Details – File Copy Changes

- What changed?
  - Reduced per-file network round trips
  - Reduced L2 cache misses and CPU churn.
  - Reduced spurious I/O activity on the system
  - Greater Parallelism
- How?
  - Core copy engine optimizations in CopyFileEx and Shell
  - Kernel optimizations in Cache Manager and Memory Manager
 - Improved SMB2 request compounding

Details – File Copy Changes

- Results
  - Improvements in local file copy
  - Faster WAN transfer for large file sets
  - Robocopy now supports multithreaded copy
    - Multi-threaded copy ("/MT" switch)
      Improvement up to 8x on high-latency networks

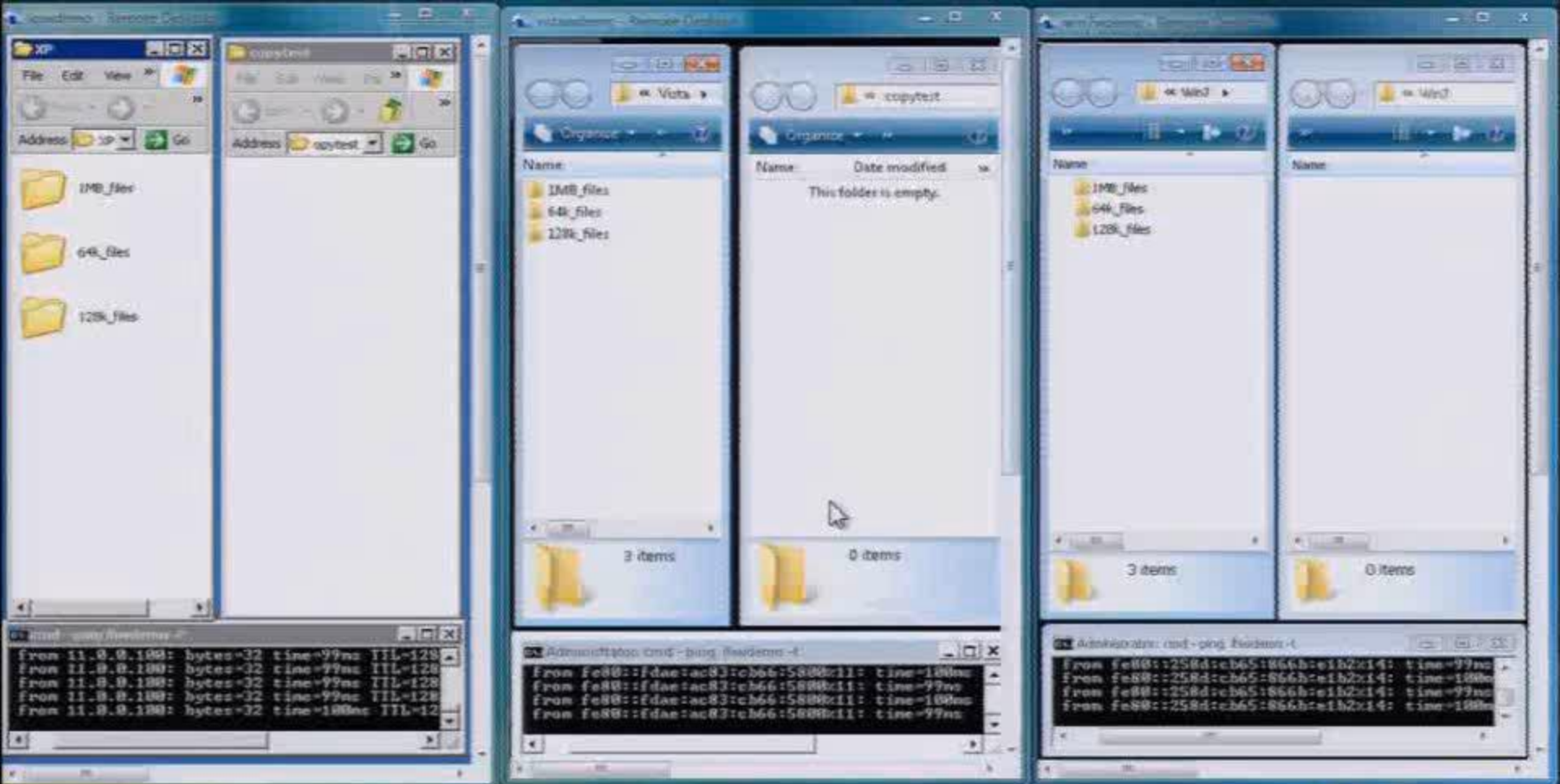# Details – WAN Office File Open
Better Together!

230%

Lower is Better

Time

250%
200%
150%
100%
50%
0%

100KB DOC   5MB DOC   100KB DOCX   5MB DOCX
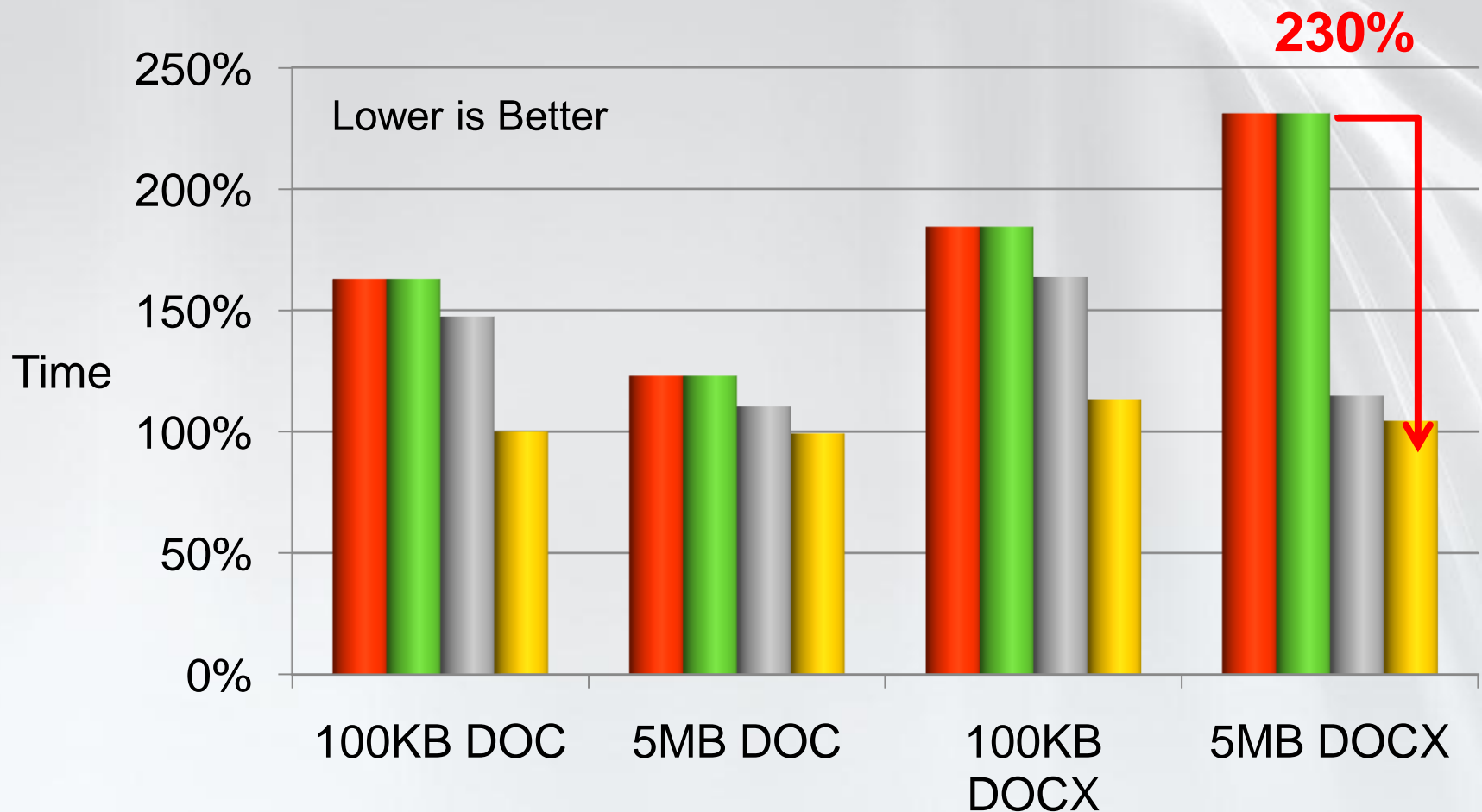
■ Vista SP2 - WS08   ■ Vista SP2 - WS08R2   ■ Win7 - WS08   ■ Win7 - WS08R2

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Performance Tuning

- Windows Hardware Developer Central (WHDC)
  http://www.microsoft.com/whdc
  - PC Fundamentals
    - Performance Page
  - Turning Guides
    - Freshly updated for R2
    http://www.microsoft.com/whdc/system/sysperf/Perf_tun_srv-R2.mspx

  - Virtualization and Partitioning
- Windows Server Performance Team Blog
  http://blogs.technet.com/winserverperformance/

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Performance Tuning
Performance Analyzer

- XPerf
  - Sampling based profiler
  - Built on top of the Event Tracing for Windows (ETW) infrastructure
- What it allows:
  - Driver delays analysis
  - CPU sampling analysis
  - Disk I/O analysis
  - Network analysis

  http://msdn.microsoft.com/en-us/performance/cc752957.aspx

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Performance Turning
XPerfView

Summary

- R2 is more than a "patch" or "service pack"
- The most scalable release of Server
- Performance gains in a number of areas
- New features to address pain points
- Great today, ready for tomorrow

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Additional Resources

- \> 64 Logical Processors
  http://code.msdn.microsoft.com/64plusLP
- Channel 9
  http://channel9.msdn.com/tags/w2k8r2
- Power savings and Management
  - Plug and Play Power Management
    http://www.microsoft.com/whdc/system/pnppwr/default.mspx
  - Power In, Dollars Out: How to Stem the Flow in the Data Center
    http://www.microsoft.com/whdc/system/pnppwr/powermgmt/Svr_Pwr_ITAdmin.mspx
- Windows Performance Analysis Developer Center:
  http://msdn.microsoft.com/en-us/performance/default.aspx

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