Removing the I/O Bottleneck in Enterprise Storage

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HITACHI DATA SYSTEMS

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Agenda

- Enterprise Storage
  - Requirements and Characteristics
  - Reengineering for Flash – removing I/O bottlenecks
- Measuring Performance
  - Application Performance Metrics vs Synthetic Benchmarks Numbers
- Summary

Requirements for Storage Systems

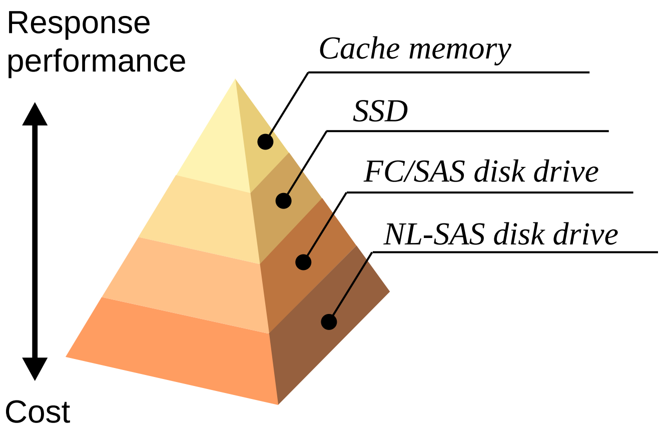
EFFECTIVELY ADDRESSING TECHNOLOGY AND BUSINESS CHALLENGES

- What Customers are demanding
  - Reduce cost, optimize service-level delivery via scale-up, dynamic provisioning and tiering across different media types
  - Management abstraction to enable ease of use, speed and automation
  - 24x7xforever application availability, eliminate planned and unplanned outages
  - Reliability, Availability Serviceability (RAS)
- Recent Trends in High-End Storage
  - Storage Subsystems are designed for the Virtual data center
  - Storage Infrastructure is transformed in Storage Services
  - Exploitation of loosely coupled vs tightly coupled Architectures

Characterizing Storage systems

ANOTHER FORM OF RAS: REDUNDANCY, ARCHITECTURE, SCALABILITY

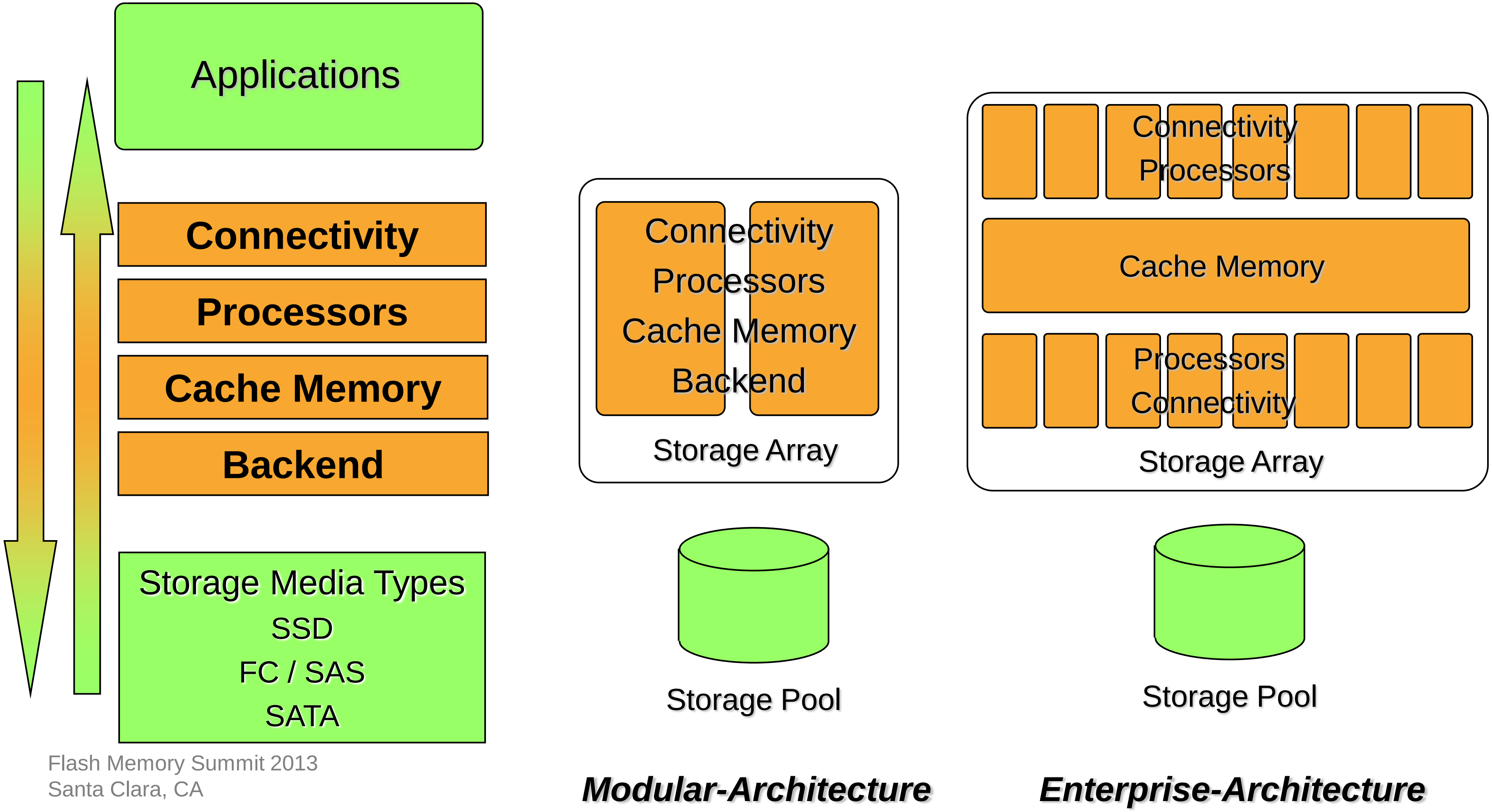
- Storage Architectures and design – different value propositions
  - Modular Architecture vs Enterprise Architecture
  - Component/Site Redundancy
- Performance
  - Time is Money – must cope with peak demands and satisfy strict SLA's



- Functionality
  - Virtualisation
  - Dynamic Tiering
  - In-System Snapshots and Clones
  - 2DC and 3DC Sync and Asynchronous Replication
  - Rich GUI/CLI Management Capabilities – Ease of Use

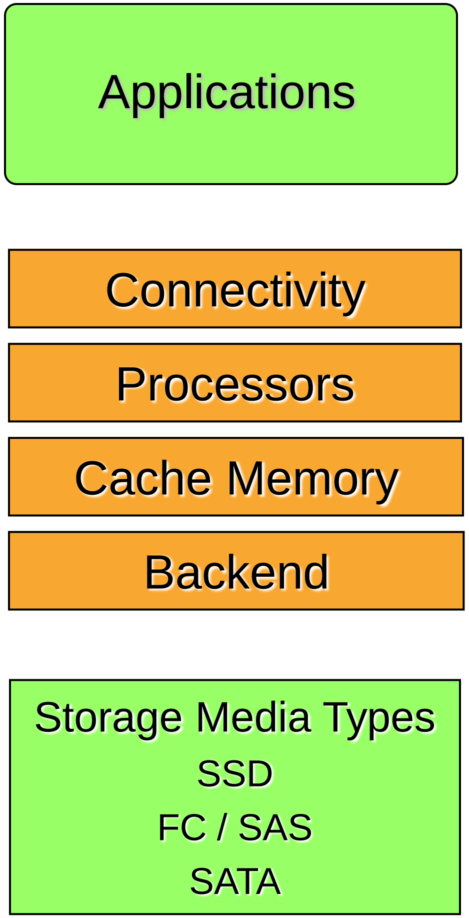
Modular vs Enterprise Architecture

BALANCING COST, SCALABILITY, PERFORMANCE AND CAPACITY



Modular storage growth – Scale-Out

ADD MORE OF THE SAME – BUT BEWARE OF ISLANDS



Applications

Connectivity

Processors

Cache Memory

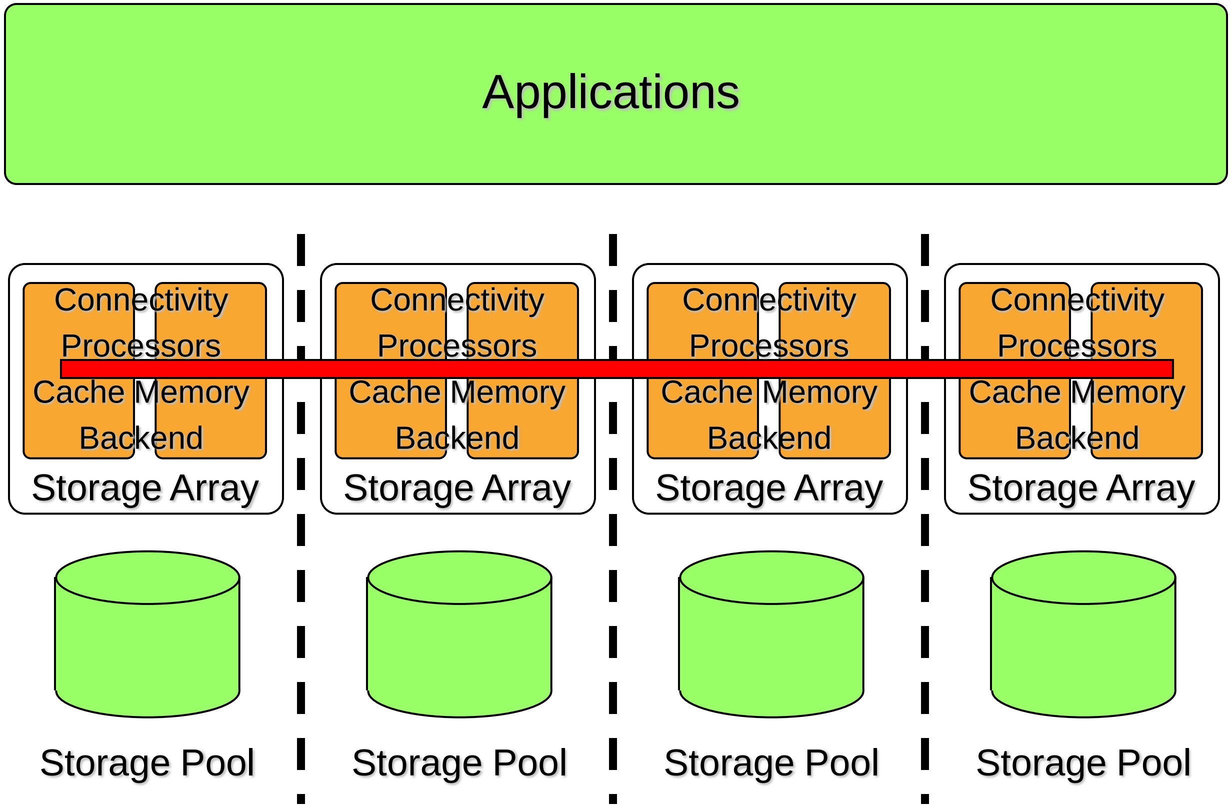
Backend

Storage Media Types

SSD

FC / SAS

SATA



Applications

Connectivity Processors Cache Memory Backend Storage Array

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Connectivity Processors Cache Memory Backend Storage Array

Storage Pool

Storage Pool

Storage Pool

Storage Pool

Loosely coupled Architecture

Enterprise storage growth – Scale-Up

EXPAND CAPACITY, CONNECTIVITY AND PROCESSING POWER

Applications

Connectivity

Processors

Cache Memory

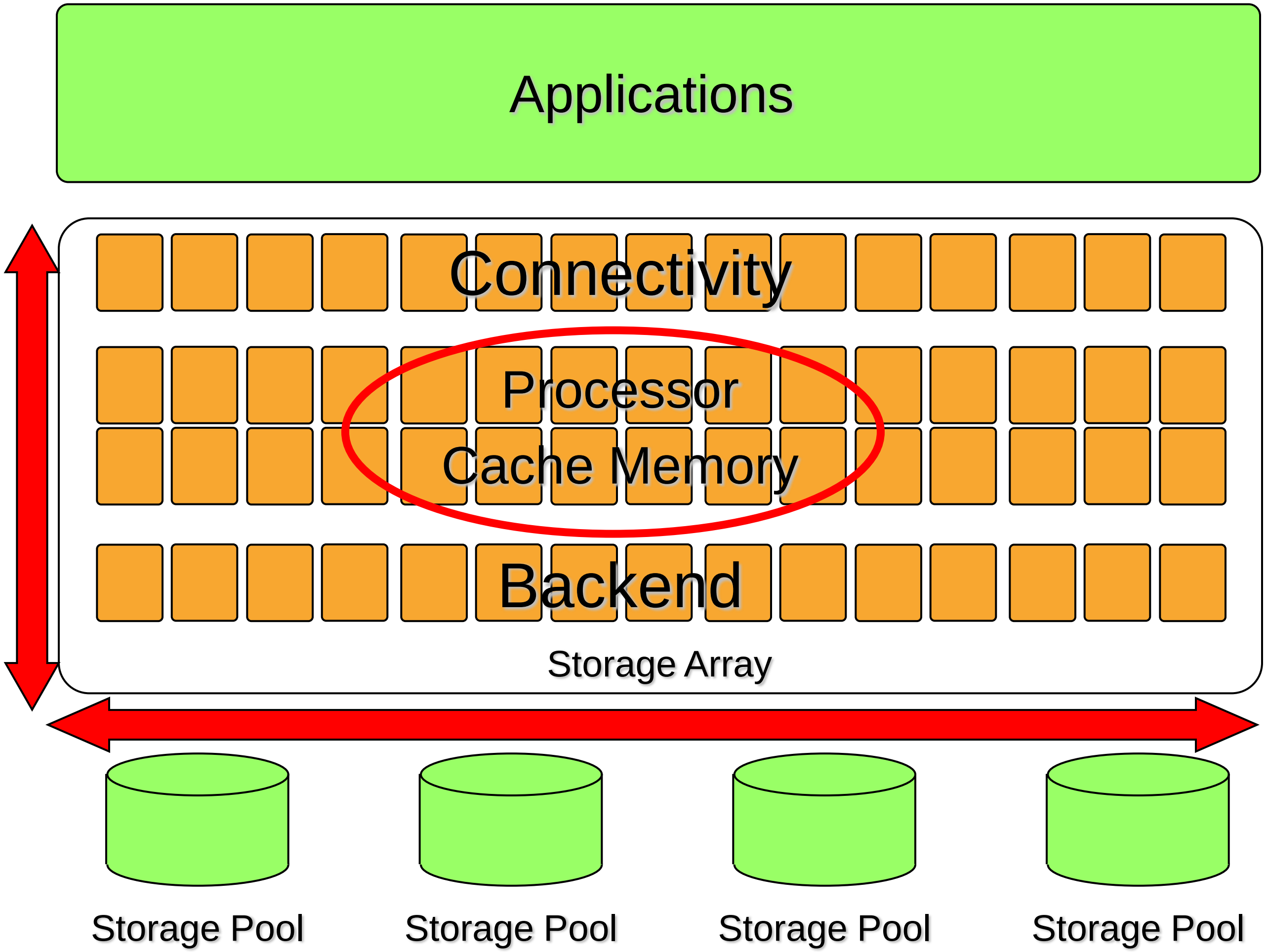
Backend

Storage Media Types

SSD

FC / SAS

SATA



Applications

Connectivity

Processor

Cache Memory

Backend

Storage Array

Storage Pool

Storage Pool

Storage Pool

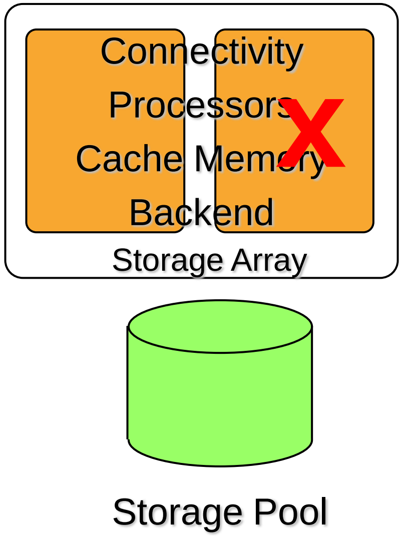
Storage Pool

Tightly coupled Architecture

When things go wrong

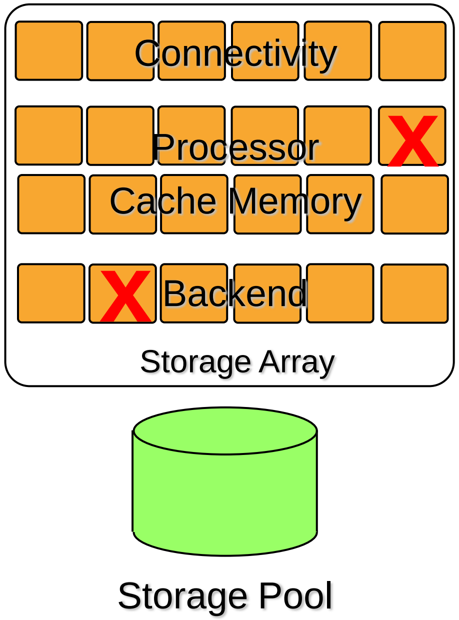
FAILURE IMPACT - GOOD ENOUGH VS BULLET PROOF

- Availability depends on failure domains and the choice of component/site redundancy options
  - Bulletproof storage array: http://www.youtube.com/watch?v=Gnjb1WVkhmU



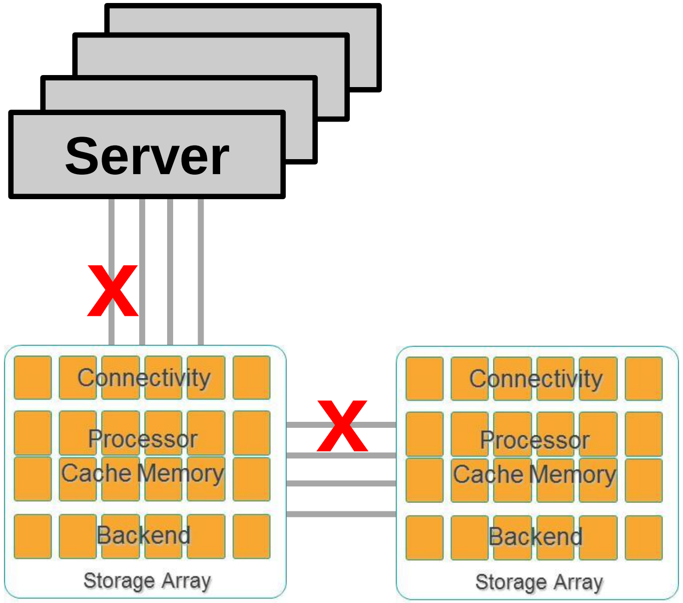
Modular-Architecture

Probably System down



Enterprise-Architecture

Relatively little impact



Component Redundancy

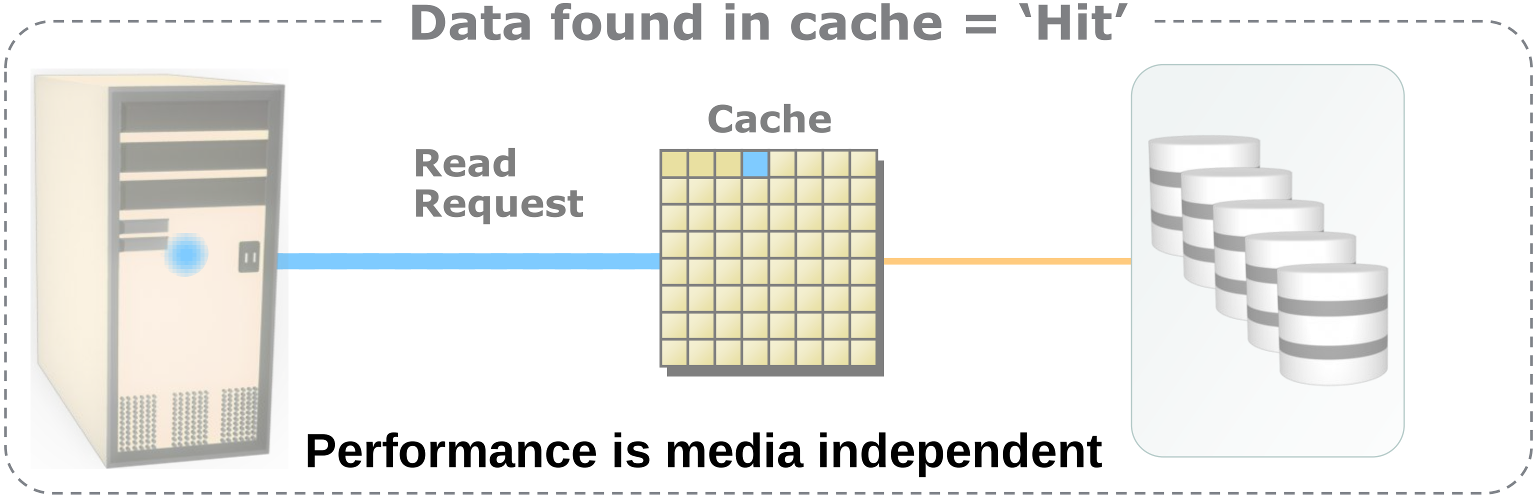
25% loss of connectivity

I/O Bottleneck in Enterprise Storage

BUILT FOR FLASH FROM THE GROUND UP VS RE-ENGINEERED

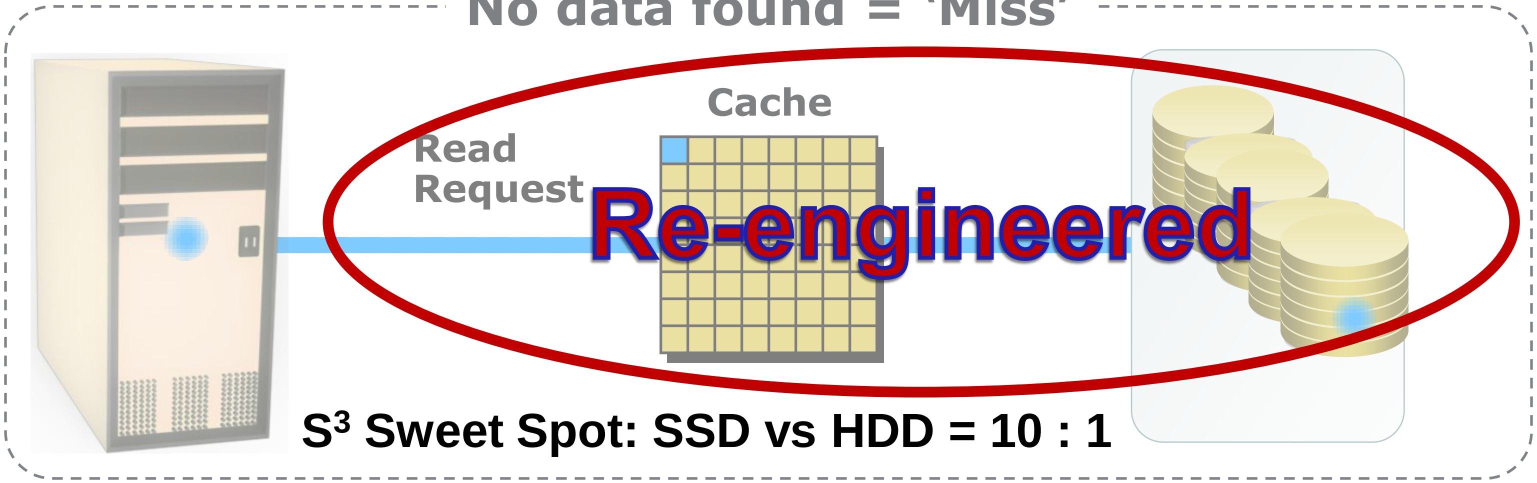
- Traditional Storage Arrays
  - originally designed for hundreds, then thousands of HDD's
  - Ever larger DRAM Cache and sophisticated Algorithms mitigate/hide HDD performance characteristics
    - Works great for sequential read/write
    - Works very well for Random I/O with good Locality of reference
- The IO Gap
  - Moore's Law - processor speed has increased dramatically
  - HDD Speed (Seek and RPM) has virtually stayed the same
  - server virtualization randomizes I/O, LOR is lost, aka «I/O Blender»
- The Emergence of Flash demands a new approach

Read IO Operation; Cache Hits and Misses



Data found in cache = 'Hit'

Performance is media independent



No data found = 'Miss'

S^3 Sweet Spot: SSD vs HDD = 10 : 1

Hitachi Innovation: Flash Acceleration

OPTIMIZING STORAGE SYSTEM SOFTWARE TO EXPLOIT FLASH

- 30+ fundamental software changes to turbo-charge performance with Flash
  - New “express” I/O processing
  - New Cache Slot Allocation method
  - Reduced ucode Overhead and path length
- Significant performance impacts
  - Up to 65% reduction in response time
  - Up to 4X Random IO scalability
- Non-disruptive installation and transparent to current applications

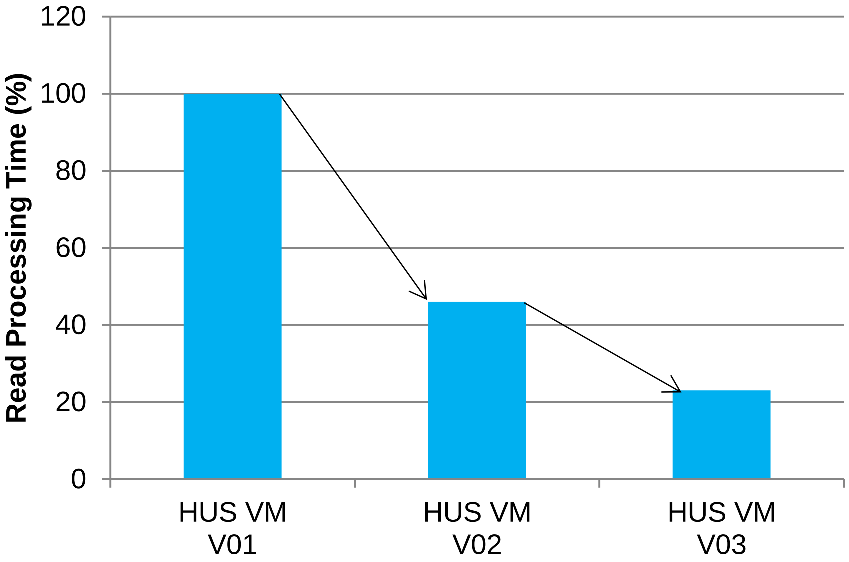
Hitachi Storage

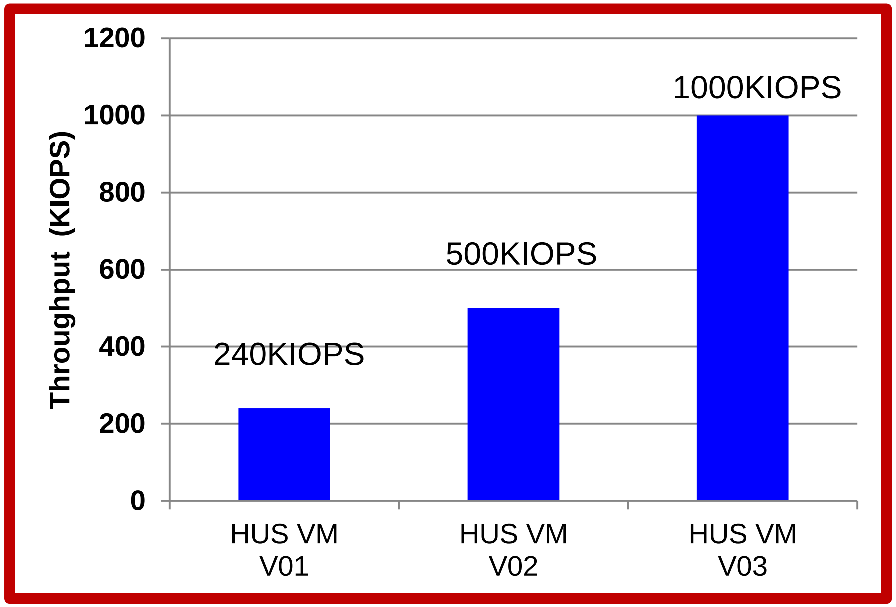
HUS VM & VSP
Optimized for
Flash
Today

Flash Acceleration Impact for all flash array

145 PATENTS RELATED TO HITACHI FLASH TECHNOLOGY

- Backend Codepath reduction, logic and ASIC optimization
  - Version 1: Basic Design for HDD – non optimized
  - Version 2: BE/FE Job Integration, Cache Buffer Slot Management
  - Version 3: use DXBF, avoid CTL to CTL communication Improve CPU L1 Cache Hit Rate for Instructions



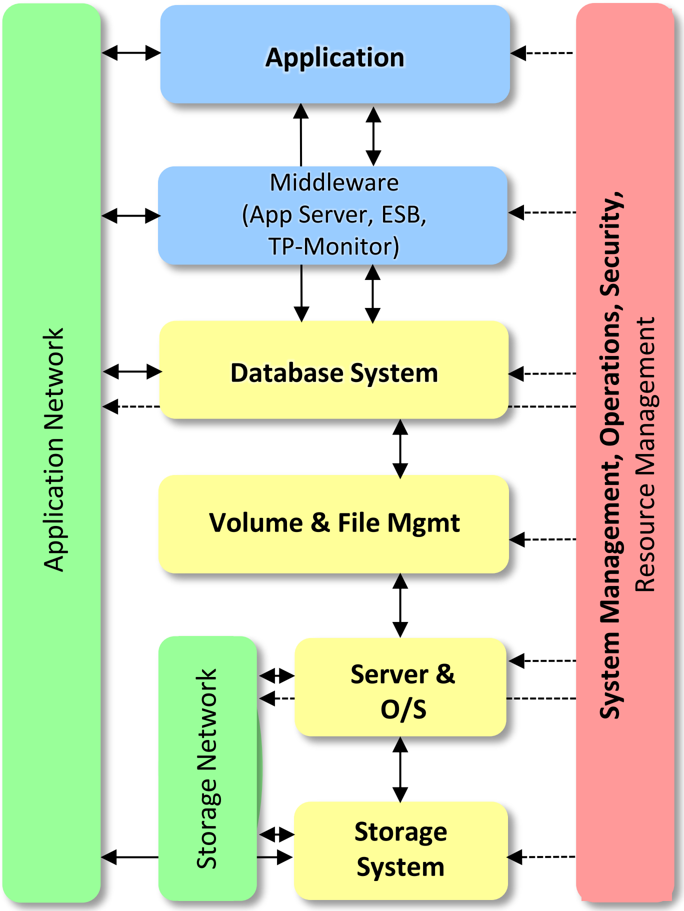


Latency and what does it really mean

MEASURING PERFORMANCE - RELEVANCE TO YOUR BUSINESS

- Vendor Provided Measurement Data
  - Objective is to show «champion numbers»
  - Customers need to have a complete understanding of what was measured and how, for example:
    - 80 usec Latency: single 512Byte Block Read measured at Fibre Channel Port with a Fibre Channel Analyzer
    - 1 Million IOPS: 4KB Random Reads measured by IOMETER
  - Interesting, but not relevant from an application perspective
- Need a different approach
  - Include and consider all the different technology layers of entire platform
  - Example: Oracle Database Platform Architecture

Oracle Database Platform Architecture



Complexity of Oracle platform

Application Network (IP-based)
Bandwidth, latency during remote database mirroring (sync, async) due to switches and sql*net and tcp/ip stack (frame size, …).

Oracle Database
Different versions, patches and options, about hundred configuration parameters.

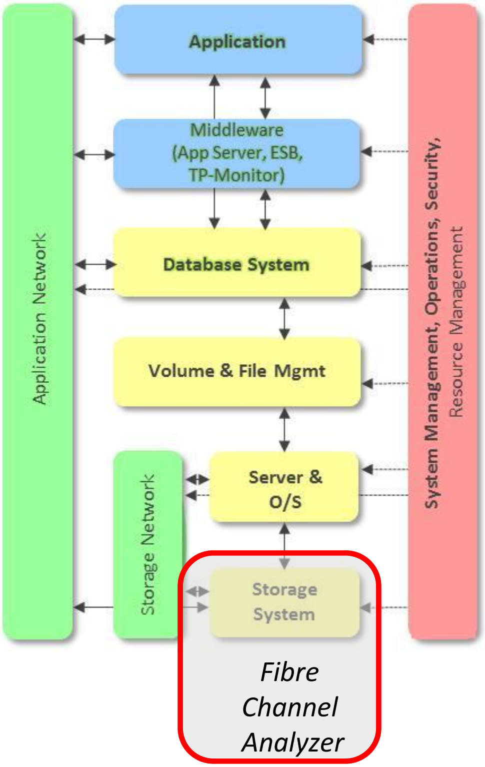
Volume & File Management
Different volume managers (VxVM, ASM) and file systems (UFS, VxFS, ext3, JFS, ZFS, raw devices), different I/O methods (async, direct), a lot of config parameters (#LUNS, queue depth, max i/o unit), software striping and/or mirroring, multipathing.

Storage Network (IB-, FC- or IP-based)
Bandwidth, latency during remote storage mirroring (sync, async) due to switches, hubs and distance.

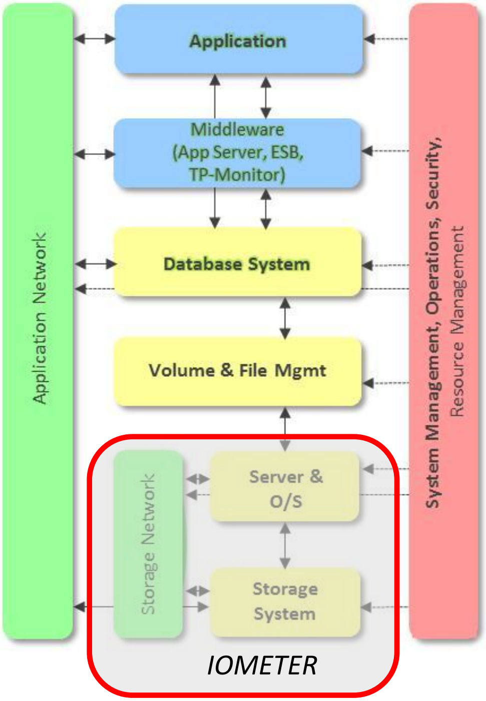
Server & Operating System
Different server systems, processors and CPU architectures, (x86, IA-64, UltraSparc, SPARC64, Power), #cores, multithreading, main memory, bus architecture. Different operating systems and patches, over hundred configuration parameters, virtualization of resources.

Storage System
Different storage systems, storage tiers and storage technology: spindle count and speed, RAID management, cache management, server interface technology, storage system options like remote copy, hardware striping and/or mirroring, virtualization of resources.

Measuring Oracle Application Performance

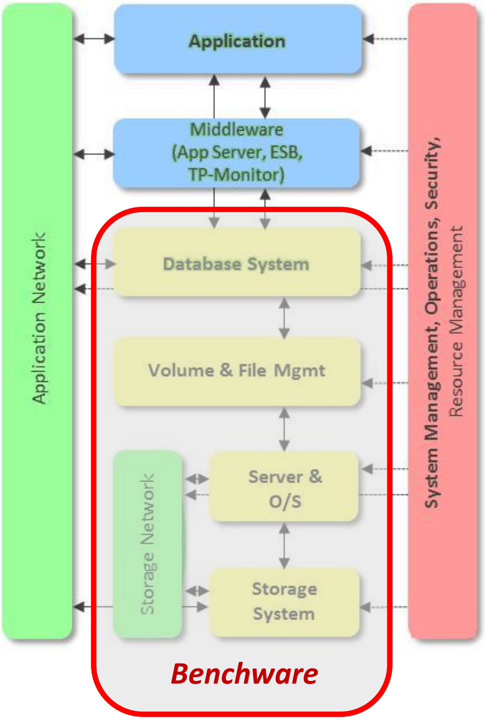


Measuring Hardware



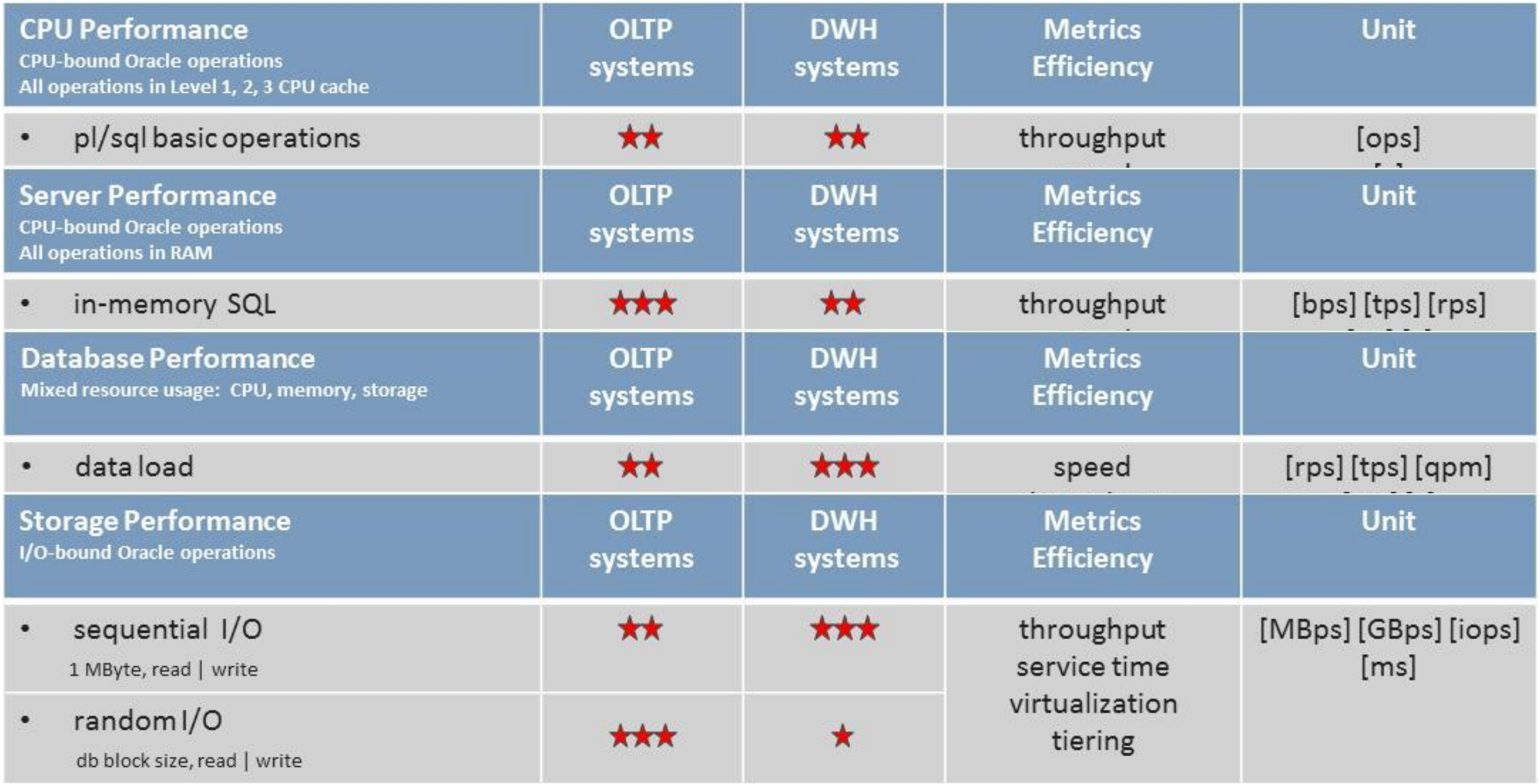
Measuring Server and Storage and «Mindless» IO

Measuring complex Application I/O or customer reality



Benchware Approach

Library of Oracle benchmark tests - implemented in PL/SQL, Java and SQL

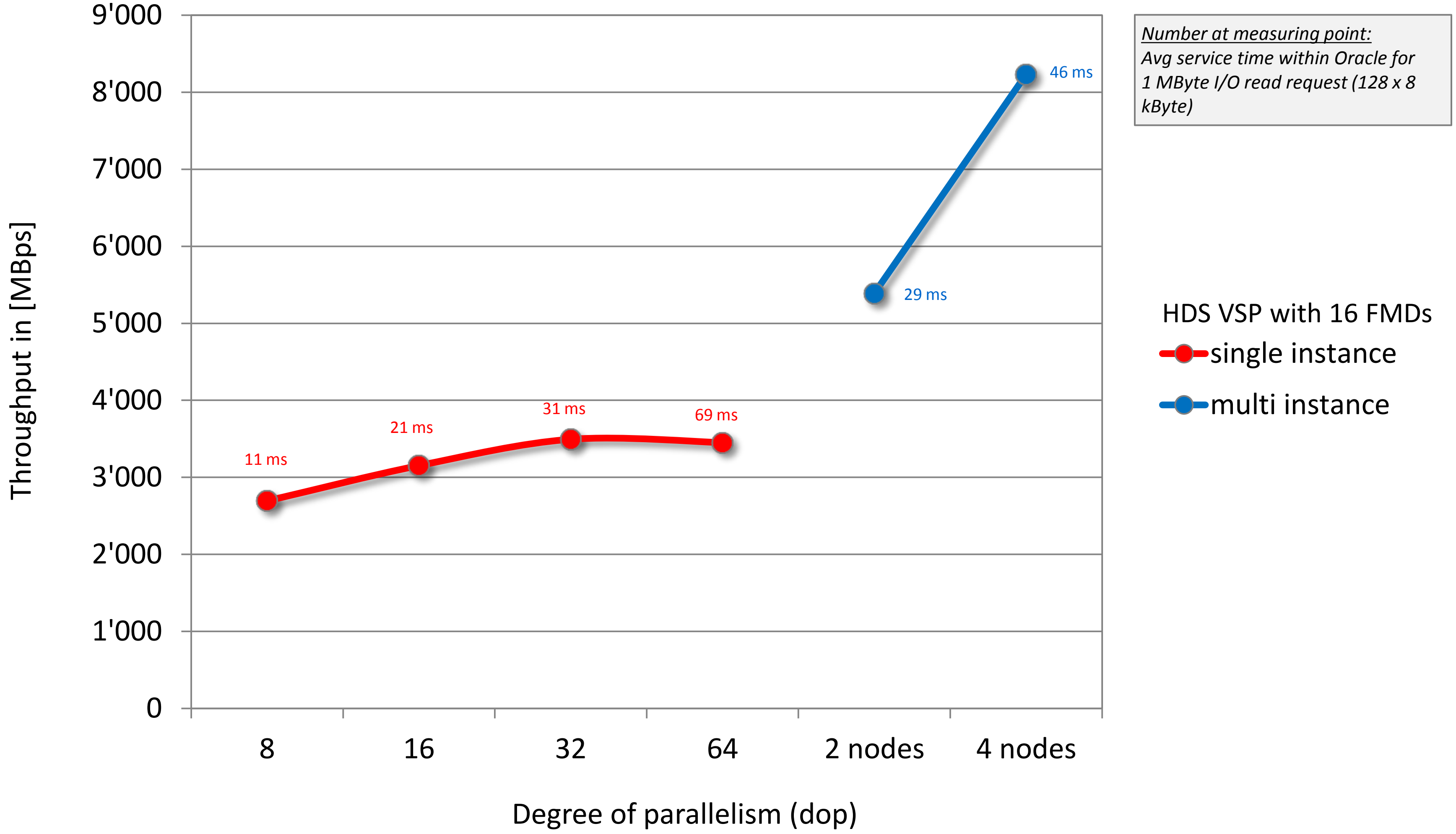


CPU Performance CPU-bound Oracle operations All operations in Level 1, 2, 3 CPU cache	**OLTP systems**	**DWH systems**	**Metrics Efficiency**	**Unit**
• pl/sql basic operations	★★	★★	throughput	[ops]
Server Performance CPU-bound Oracle operations All operations in RAM	**OLTP systems**	**DWH systems**	**Metrics Efficiency**	**Unit**
• in-memory SQL	★★★	★★	throughput	[bps] [tps] [rps]
Database Performance Mixed resource usage: CPU, memory, storage	**OLTP systems**	**DWH systems**	**Metrics Efficiency**	**Unit**
• data load	★★	★★★	speed	[rps] [tps] [qpm]
Storage Performance I/O-bound Oracle operations	**OLTP systems**	**DWH systems**	**Metrics Efficiency**	**Unit**
• sequential I/O 1 MByte, read | write	★★	★★★	throughput service time virtualization tiering	[MBps] [GBps] [iops] [ms]
• random I/O db block size, read | write	★★★	★		

[s]	seconds	[bps]	buffers per second	[MBps]	mega bytes per second	★	less important
[ms]	milli seconds (10^{-3})	[rps]	rows per second	[GBps]	giga bytes per second	★★	important
[µs]	micro seconds (10^{-6})	[tps]	transactions per second	[iops]	i/o operations per second	★★★	very important
[ns]	nano seconds (10^{-9})	[ops]	operations per second	[qpm]	queries per minute		

Measuring Datawarehouse Workload

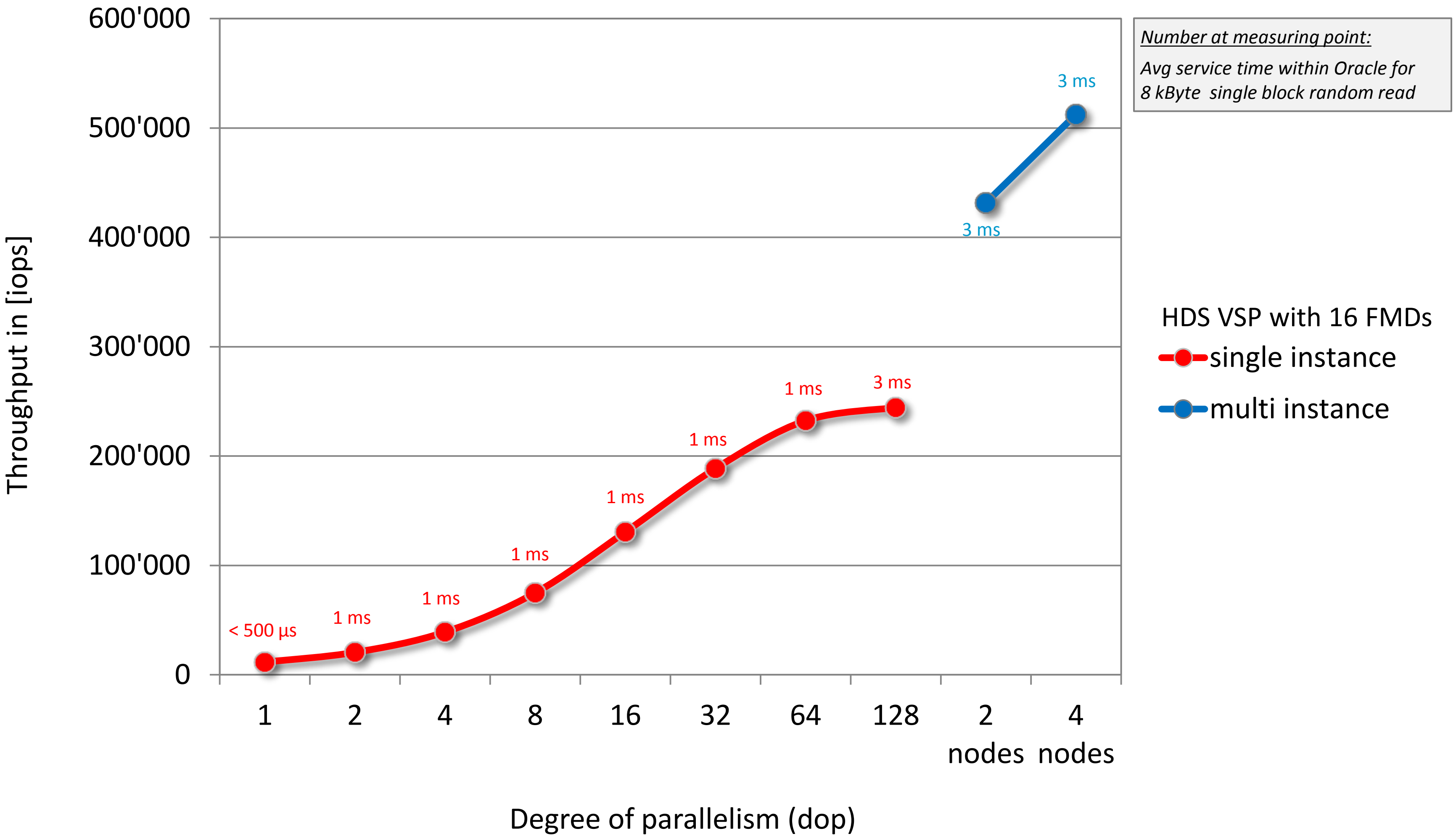
SEQUENTIAL READ, MULTIPLE PROCESSES – TYPICAL FOR DWH



__Number at measuring point:__
Avg service time within Oracle for 1 MByte I/O read request (128 x 8 kByte)

Measuring OLTP Workload

8KB RANDOM READ; 100% CACHE MISS - TYPICAL FOR OLTP



Number at measuring point:

Avg service time within Oracle for 8 kByte single block random read

What does it mean to your business?

KEY PERFORMANCE METRICS LEAD TO SERVICE LEVEL AGREEMENTS

- The measured server/storage platform will deliver:
  - 8GB/sec sequential Read throughput for your DWH
  - 250’000 8KB Random Reads with Zero Cache Hits for your OLTP application with a Response Time of less than 3 Milliseconds

- Note: Oracle Measurements for Random Read IO
  - Oracle currently does not understand «Microseconds»
  - Response Time for Random Read is reported in Milliseconds, and data is rounded e.g. 0 MS or 1 MS
- R/T for high Random Read I/O Rates generally at 1-4 MS
  - This also applies to All Flash Appliances/Arrays

Summary

- Enterprise Storage today has a lot to offer
  - RAS: Reliability, Availability, Serviceability
  - Superior Performance
  - Seamless Scale-Up Architecture
- Flash Storage Exploitation
  - Value of Re-engineering equals «Built from scratch»
  - In addition you get the functionality and EoU you need
- Performance and Latency Claims
  - Must understand what is being measured and how
  - The key is the mileage you get for your application!

Questions and discussion

Thank you