Accelerating Applications and System Performance with Flash, Intelligently and Efficiently

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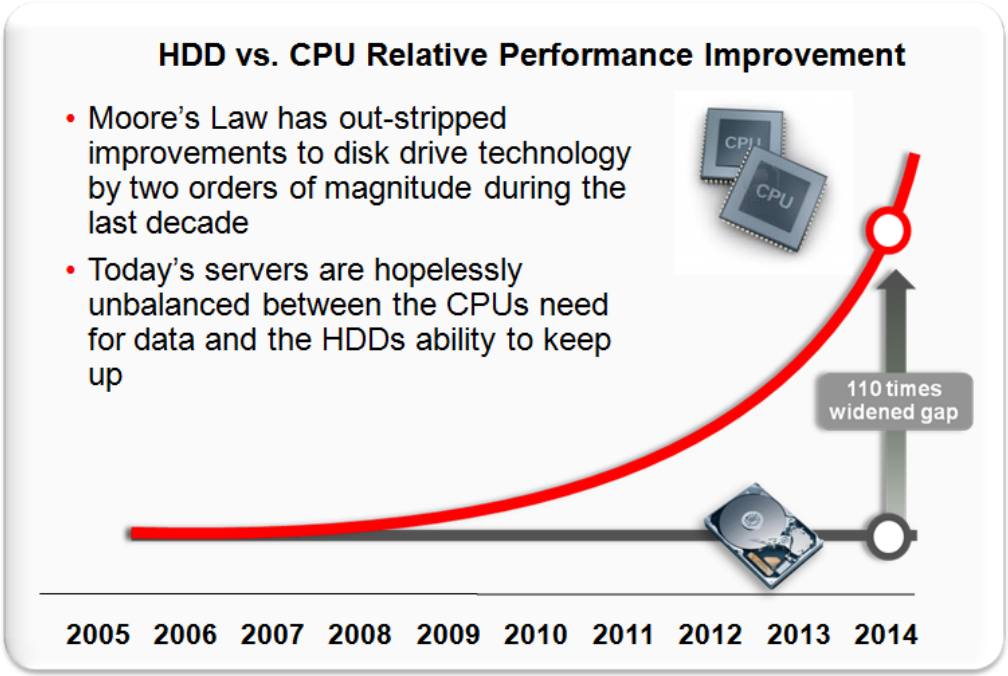
Problem: Server and Storage Discontinuity

CPUs have become I/O starved



- Today multi-core, multi-socket servers are increasingly being held back by slow storage as they wait for data
- Application performance remains sluggish regardless of the Server CPU horsepower
- Flash helps eliminated storage I/O bottlenecks, increase system efficiency and application performance

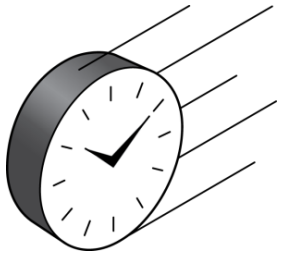
Flash

Ideal for accelerating today's high-performance, latency-sensitive workloads, like **Databases**

- **Reduces latency**
- Improves response times
- Increases I/O throughput
- Accelerates applications
- Improves productivity and TCO

Flash Everywhere

Oracle uses Flash as cache and storage across most systems in a highly Integrated, intelligent way



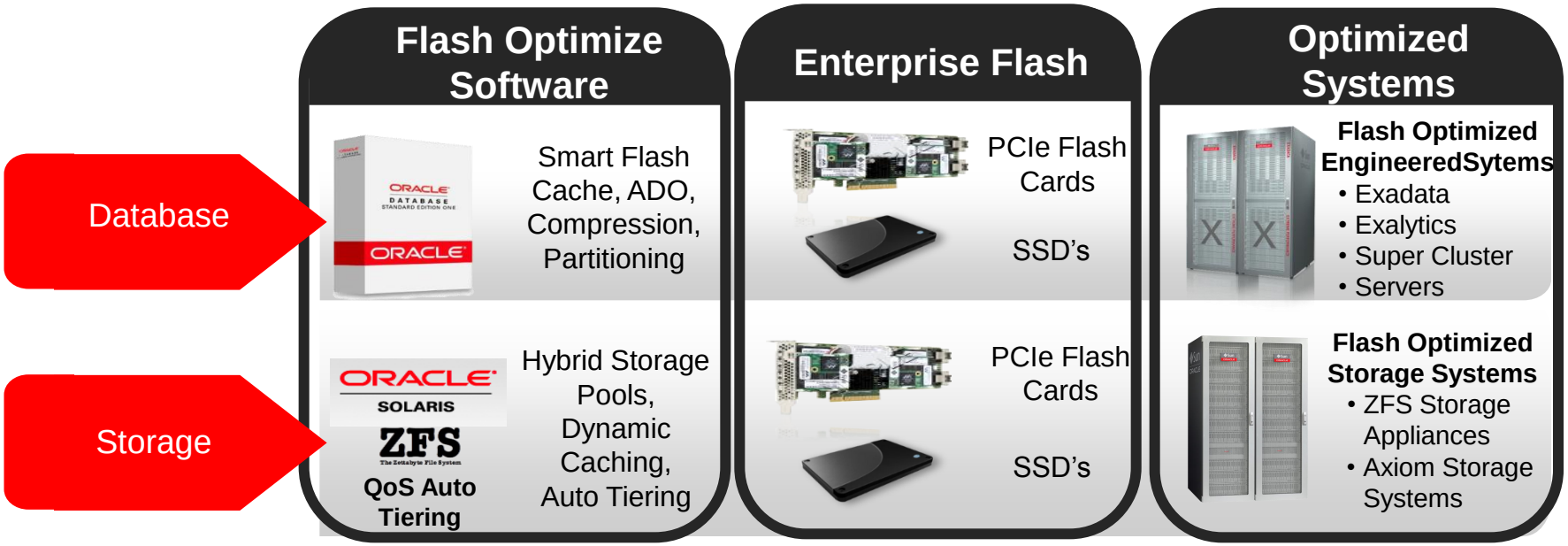
Intelligent

We Love ♡ Flash

- Servers
  - SPARC and x86 Servers
- Application Engineered Systems
  - Exadata Database Machine
  - Exalytics In-Memory Machine
  - Oracle Super Cluster
  - Oracle Database Appliance
- NAS Storage Systems
  - ZFS Storage Appliance
- SAN Storage Systems
  - Axiom Storage System
- Flash Enabled Software
  - Flash enabled Database
  - Flash enabled OS/File System
  - Flash enabled Storage Caching and Tiering

Oracle's Software Driven Flash Strategy

Intelligent, optimized integration with Oracle's software and systems for maximum performance, ease-of-use and efficiency



Maximizing Benefits of Flash Transparently

Hardware and Software
Engineered to Work Together

Server Flash

In-server Flash for accelerating performance and server efficiency/utilization

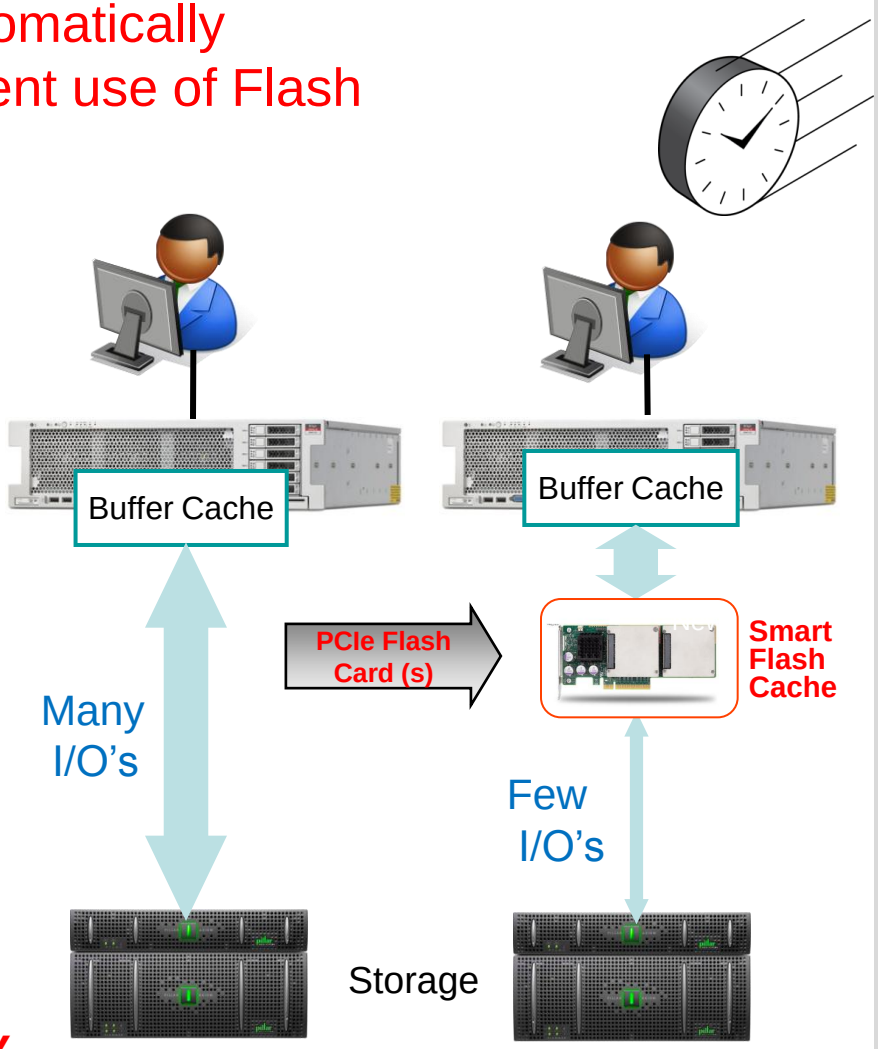
- SPARC Servers
  - Enterprise SSDs and PCIe Flash Cards
- X86 Servers
  - Enterprise SSDs and PCIe Flash Cards
- Flash Enabled SW
  - Solaris OS with ZFS File System
  - Database Smart Flash Cache

Best performance and latency benefits closer to CPU

Database Smart Flash Cache SW *

Improves performance automatically
Highly efficient and intelligent use of Flash

- Transparent memory extension with Flash
- Acts as Level 2 Buffer Cache (SGA)
  - Easy way to increase cache size
- Intelligent, dynamic and easy-to-use
  - Automatic management of hot data
- Provides up to 15X faster I/O service times than HDD
- Minimizes disk storage I/O demands
- Improves I/O throughput and response times
- Great for accelerating read intensive I/O workloads, like OLTP (*reduces "db file sequential reads" wait times, as per dB AWR*)



Benefits: Faster performance, better response times , increased productivity

* Oracle Database SW feature (starting with 11gR2)

Oracle's Flash Optimized Engineered Systems

Exadata X4-8, with Smart Flash Cache

World's Fastest Database Machine

- 240 database server CPU cores
- 168 storage server CPU cores
- 12TB system memory
- **Up to 350TB of effective Flash Cache**
  - With Smart Flash Cache and DB compression

- 672 TB of disk
- InfiniBand Internal Fabric
- Flash enabled DB with Smart Flash Cache
  - Dynamic read/write caching software

Extreme Performance !

Intelligent use of Flash

Flash Optimized NAS Storage

High performance Hybrid Storage

Oracle's ZS3 Storage Appliance

Highest Performance, Highest Efficiency Hybrid Storage System

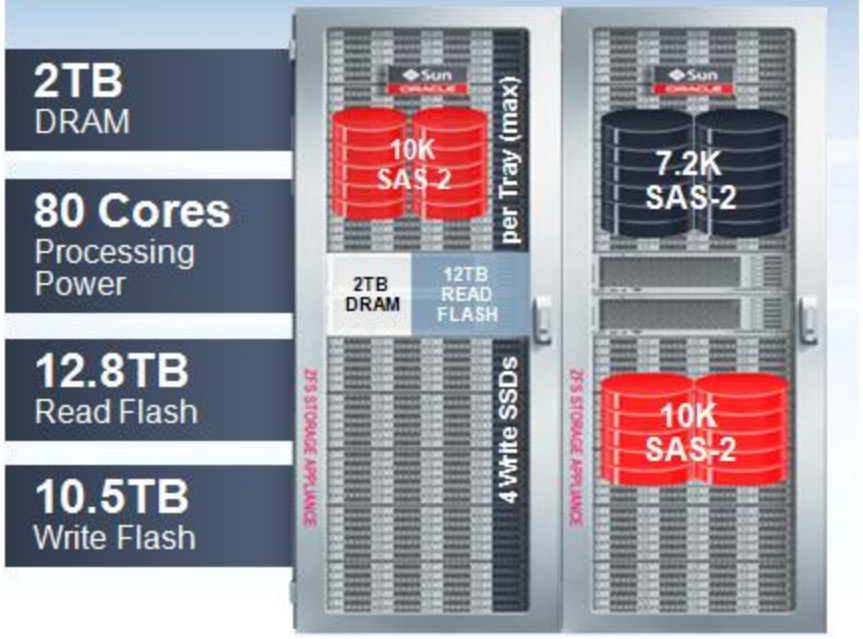
- **World-Record Performance**
  Accelerate High-throughput Business Analytics and Database Queries
- **Best Price/Performance Efficiency**
  Optimum Price/Performance Economics and $/IOPS, $/GB mix
- **DRAM/Flash/HDD Optimized**
  Dynamic Caching and Storage Tiering (HSP)

Record performance based on ZS3 performance results with SPC-2 and SPECsfs benchmarks
Most economical claim based on a combination of the SPC-2TM benchmark results and use of Oracle Hybrid Columnar Compression.

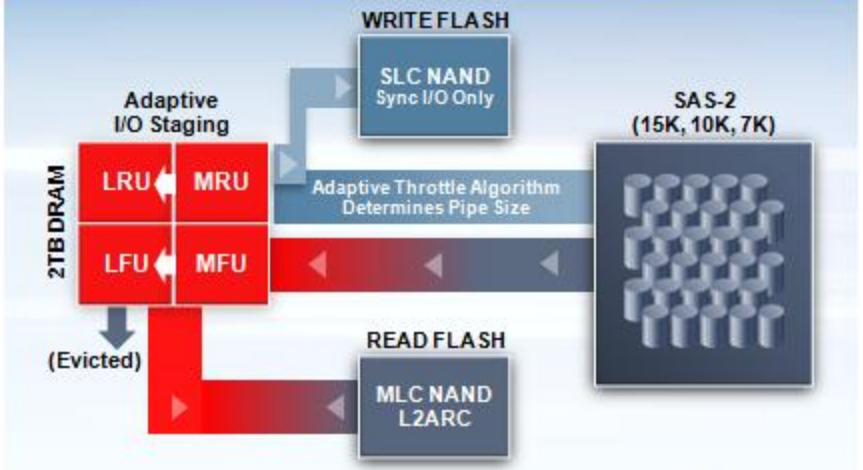
ZS3 NAS Storage Appliance

Egineered for extreme performance and economics

Most Horsepower Possible



Dynamic Storage Tiering (HSP)



- Automated, real-time data migration from DRAM to multi-class flash, to multi-class disk storage
- Software specifically engineered for multi-level flash and disk storage

Why Hybrid Storage

- Best $/IOPS and $/GB economics
- Offers speed of flash with the capacity and cost of disk
- Ideal for most workloads
- A large DRAM cache design can often outperform All-flash arrays

Not all data is hot, and its "temperature" varies with time

Flash Optimized SAN Storage

Engineered with QoS-driven auto tiering

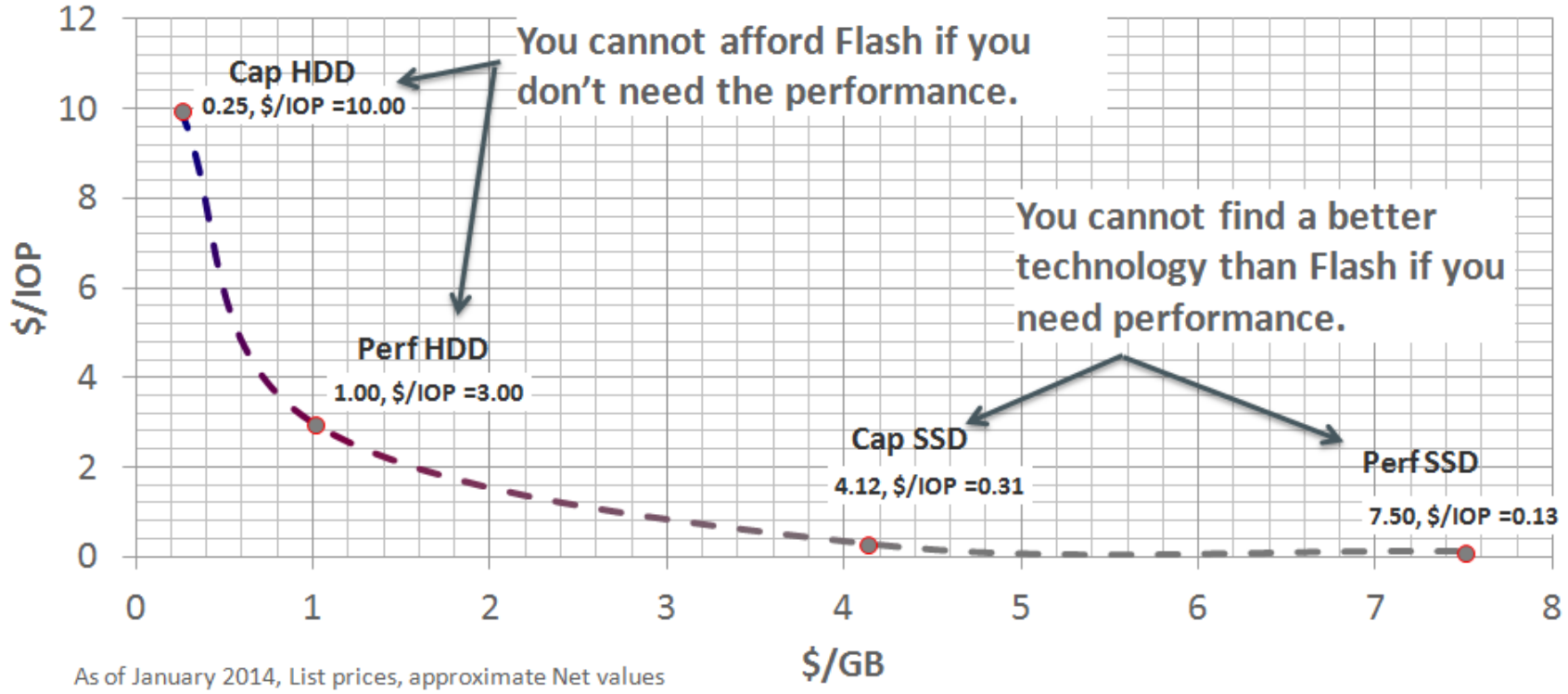
Oracle's Axiom Storage System

QoS and Auto-Tiering Optimized

- **Auto Tiering**
  Adaptive granular multi-flash, multi-disk tiering
- **QoS Management**
  Aligns business priorities with price/performance value
- **Flexible Hybrid to All Flash**
  Flexible configuration mix and scale

Cost-Performance of Storage Technology

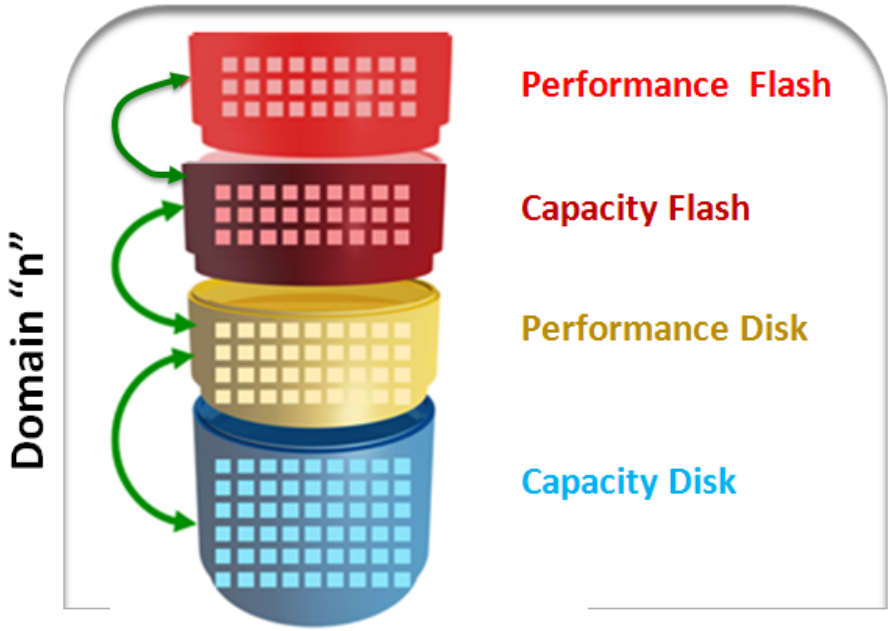
Order of magnitude difference must be exploited to optimize solution

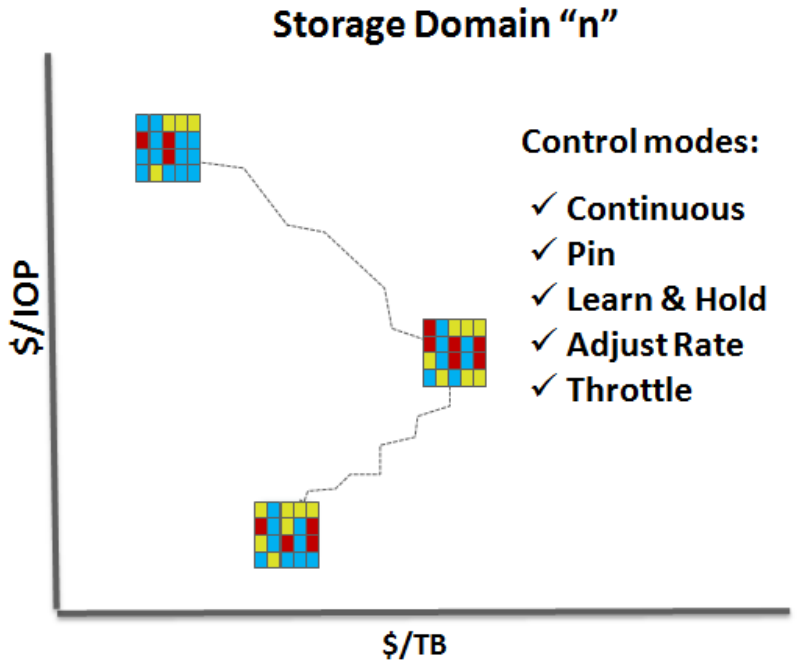


QoS Plus: Market Leading QoS-Driven Auto Tiering

Adapts to Lowest Cost & Highest Performance by Business Priority

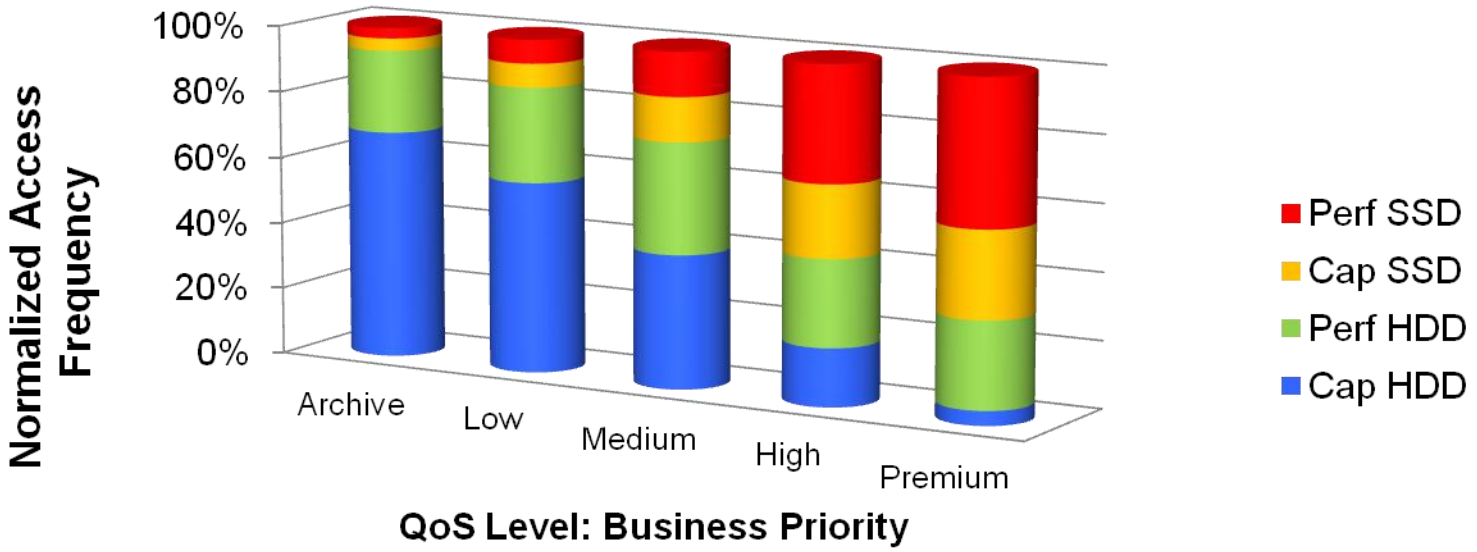
QoS Plus: a policy-based virtualization feature incorporating business priority and performance optimization fused with sub-LUN automatic tiering into one simple management framework.





QoS Plus: QoS fused with Auto-Tiering

Optimizing storage resources with most appropriate business priority for a given workload



Oracle Flash Optimization

Maximizing Customer Value

Customer Benefits

- Increased Performance
- Improved Business Response
- Increased Productivity
- Improved Efficiency
- Reduced Cost

Hardware and Software
ORACLE
Engineered to Work Together

Intelligent Integration across the whole Oracle stack

- Best Performance
- Best Efficiency
- Best Reliability
- Best Ease-of-use