Flash Memory SUMMIT

Deploying Flash in the Data Center

Or How this Flash

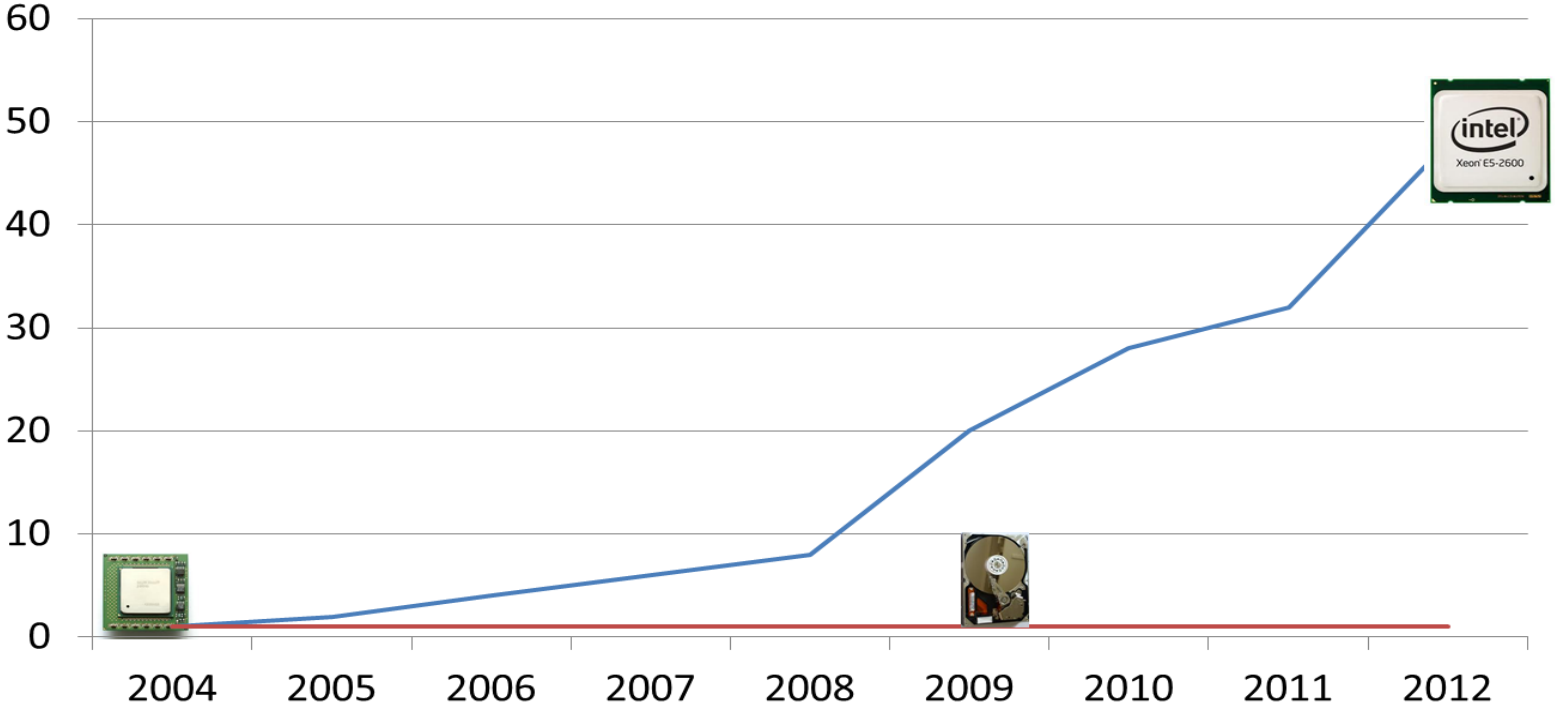
Makes Storage Like This Flash

Today's Agenda

- The storage performance problem
- Flash to the rescue
  - A brief flash memory primer
  - Flash/SSD types and form factors
- The All Flash Arrays (AFA)
- Hybrid arrays
- Server side flash
- Converged architectures
- Choosing a solution

The IO Gap

- Processor speed doubles every 2-3 years
- Disks have been stuck at 15K RPM since 2000

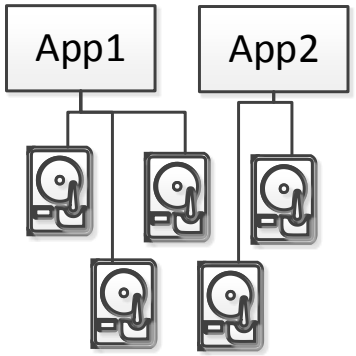


"The I/O Blender" Strains Storage

- Virtualization throws I/O into a blender… all I/O is now random I/O!
- 10 VMs doing sequential I/O to the same datastore=random I/O
- Disk drives are good at sequential, less good at random

The Noisy Neighbor Moves In

- Dedicated spindles are like solid walls
  - Applications have limited effect on each other
    - Backups excepted – Same data
- Shared datastores provide no protection
  - 1 application demanding 10,000 IOPS will slow the others.



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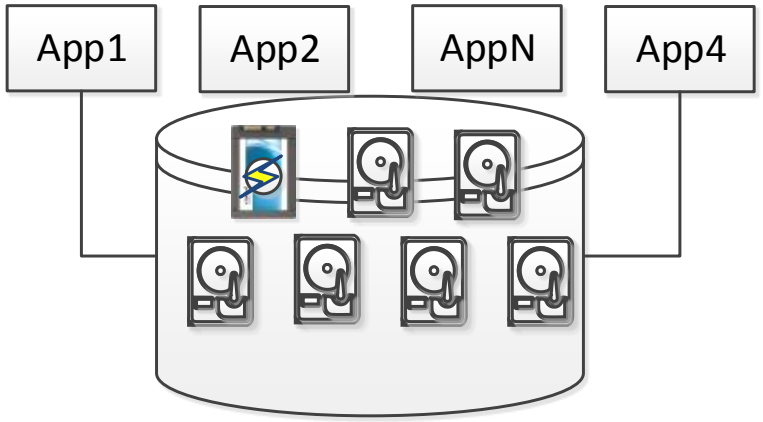
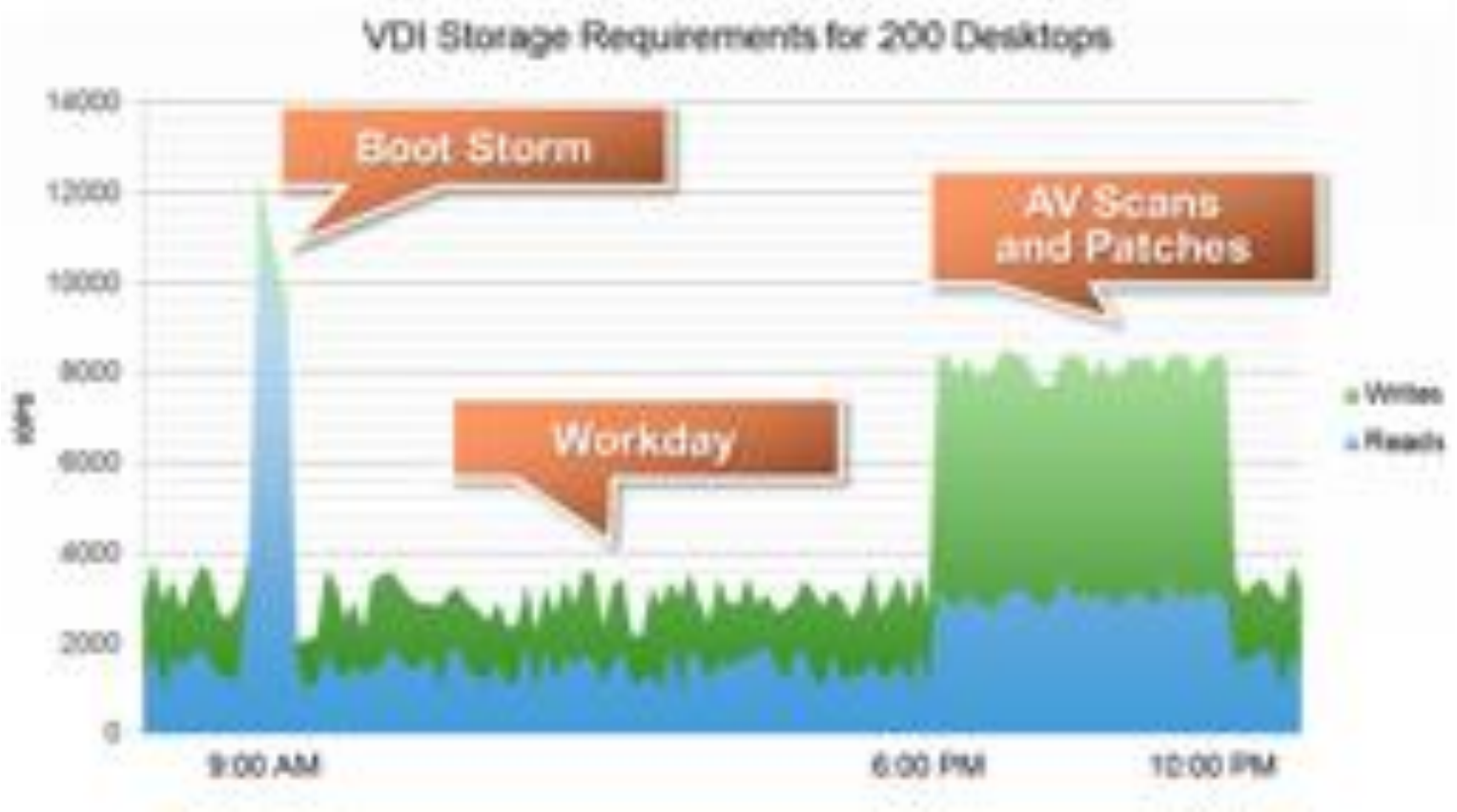


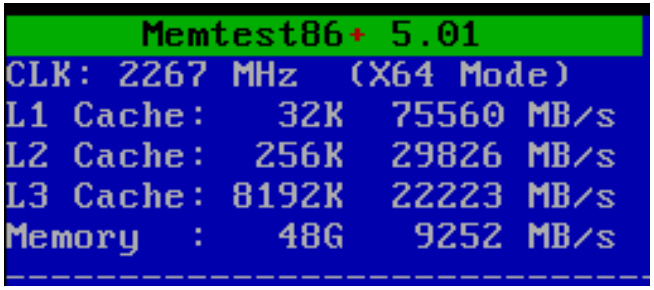
Now

VDI Presents Unique Workloads

- Highly variable but coincident (boot/login in AM)
- Steady state 50+% write
- 40+% of projects fail due to storage performance



Data Access Performance



- L1 processor cache ~1ns
- L2 processor cache ~4ns
- Main memory ~100ns
- PCIe SSD read 16-60µs (16,000-60,00ns)
- SAS/SATA SSD read 50-200µs (50,000-200,000ns)
- Disk read 4-50ms (4-50,000,000ns)

Moral of the story: keep IOPS away from the disk

Traditional Performance Solutions

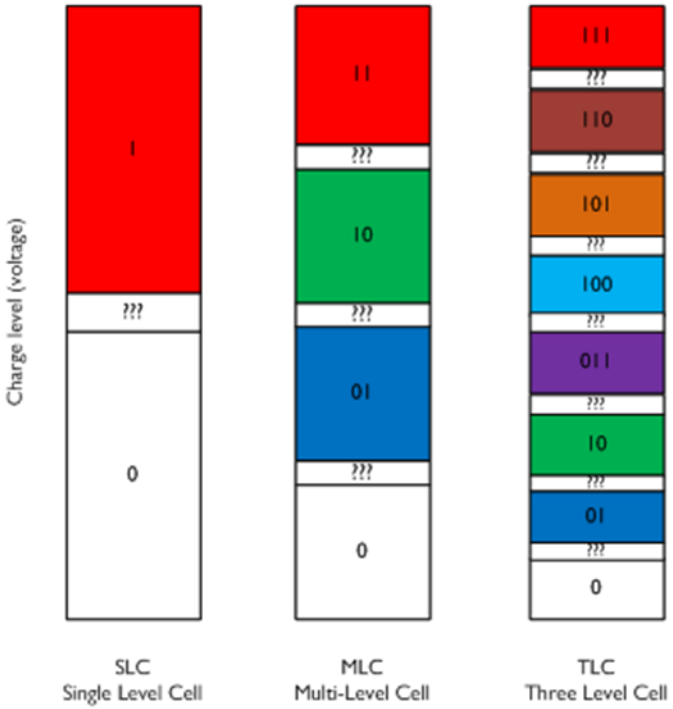
- Head per track disk drives, DRAM SSDs
  - Huge price premium limits use to the very few
- Wide Striping
  - A 15K RPM disk delivers 200 IOPS
  - For 10,000 IOPS spread load across 50 drives
    - Of course that's 15PB of capacity
  - Short stroking
    - Use just outside tracks to cut latency
- Wasting capacity wastes $ and OpEx (power, maint)

What Is Flash Memory?

- Solid State, Non-volatile memory
  - Stored charge device
  - Not as fast as DRAM but retains
- Read/Write blocks but must erase 256KB-1MB pages
  - Erase takes 2ms or more
  - Erase wears out cells
- Writes always slower than reads

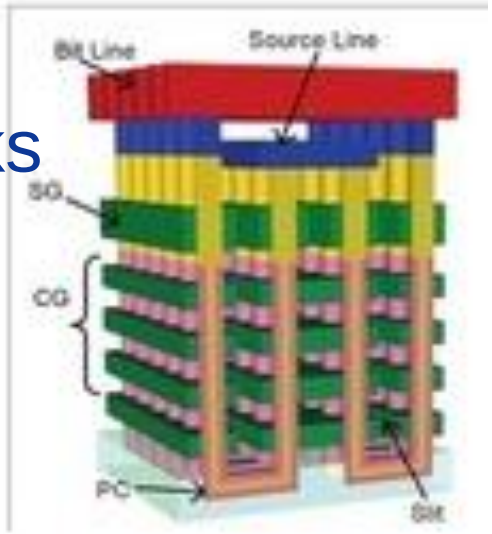
The Three, & ½, Types of Flash

- Single Level Cell (SLC) (1bit/cell)
  - Fastest
  - 100,000 program/erase cycle lifetime
- Multi Level Cell (MLC) (2 bits/cell)
  - Slower
  - 10,000 program/erase cycle lifetime
- eMLC or HET MLC (2 bits/cell)
  - Slightly slower writes
  - 30,000 cycles
- Triple Level Cell (TLC) (3 bits/cell)
  - Not ready for data center use
  - Phones, tablets, maybe laptops



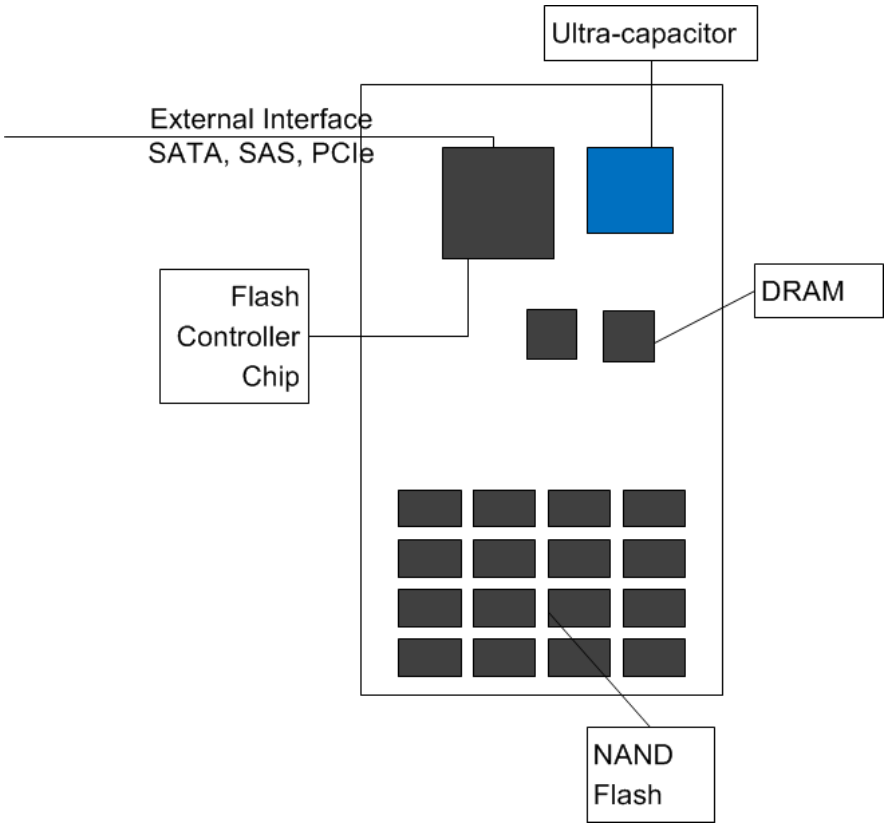
Flash's Future

- Today's state of the art flash 1x nm cells (17-19nm)
- Most shipping SSDs still 24nm
- Smaller cells are denser, cheaper, crappier
- Samsung now shipping 3d
  - Because they couldn't get Hi-k to work
- Other foundries have 1-2 more shrinks
- Other technologies post 2020
  - PCM, Memristors, Spin Torque, Etc.



Anatomy of an SSD

- Flash Controller
  - Provides external interface
    - SATA
    - SAS
    - PCIe
  - Wear leveling
  - Error correction
- DRAM
  - Write buffer
  - Metadata
- Ultra or other capacitor
  - Power failure DRAM dump
  - Enterprise SSDs only



Flash/SSD Form Factors

- SATA 2.5”
  - The standard for laptops, good for ser
- SAS 2.5”
  - Dual ports for dual controller arrays
- PCIe
  - Lower latency, higher bandwidth
  - Blades require special form factors
- SATA Express
  - 2.5” PCIe frequently with NVMe

SSDs use Flash but Flash≠SSD

- Fusion-IO cards
  - Atomic Writes
    - Send multiple writes (eg: parts of a database transaction)
  - Key-Value Store
  - FTL runs in host CPU
- NVMe
  - PCIe but with more, deeper queues
- Memory Channel Flash (SanDisk UltraDIMM)
  - Block storage or direct memory
  - Write latency as low as 3µsec
  - Requires BIOS support
  - Pricey

Selecting SSDs

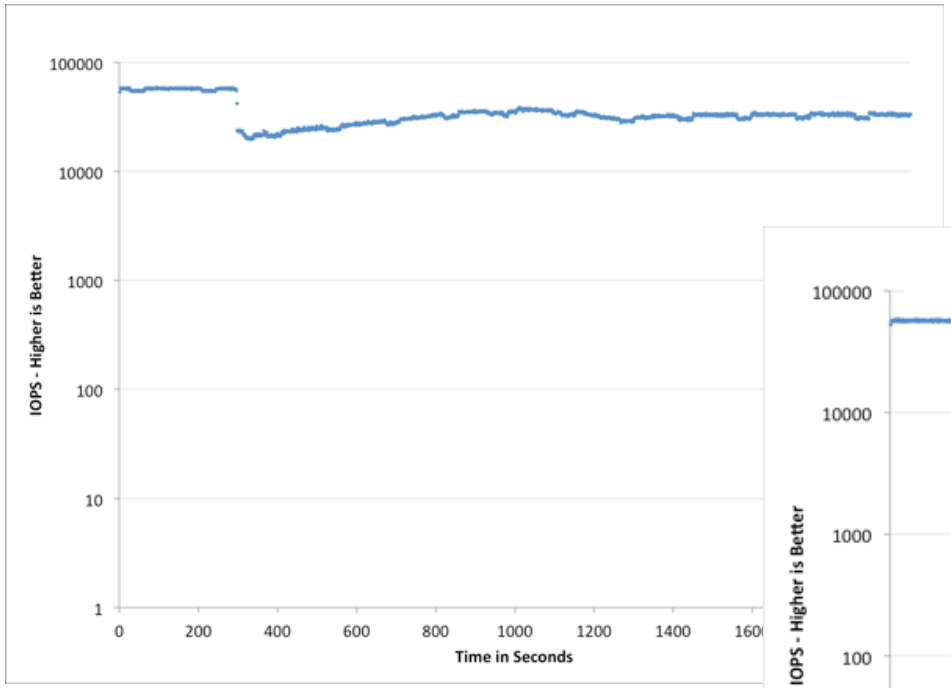
- Trust your OEM's qualification
  - They really do test
- Most applications won't need 100K IOPS
- Endurance ≠ reliability
  - SSDs more reliable than HDDs
    - 2 million hr MTBF
    - 10^17 BER vs 10^15 for near line HDD
  - Wear out is predictable
  - Consider treating SSDs as consumables
  - However don't use read optimized drive in write heavy environment

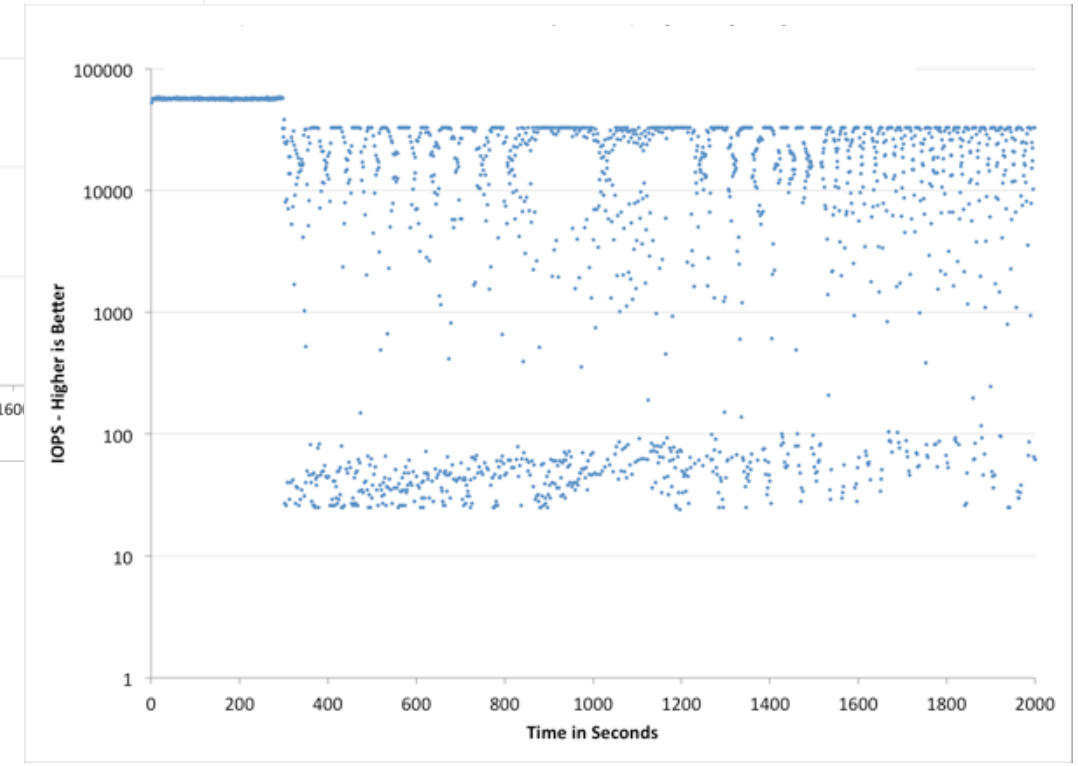
SanDisk's Enterprise SATA SSDs

Name	Sizes	IOPS r/w	Endurance	Application
Eco	240, 480, 960	80K/15K	1 DWPD, 3yr	Read intensive
Ascend	240, 480, 960	75K/14K	1 DWPD, 3yr	Read intensive
Ultra	200, 400, 800	75K/25K	3 DWPD, 5yr	General purpose
Extreme	100, 200, 400, 800	75K/25K	10 DWPD, 5yr	Write intensive

DWPD = Drive Writes Per Day

Consistent Performance is Key





Flash for Acceleration

- There are 31 flavors of flash usage
- What's best for you depends on your:
  - Application mix
  - IOPS demand
  - Tolerance of variable performance
  - Pocketbook
  - Organizational politics

Basic Deployment Models

- SSDs in server as disk
- All solid state array
- Hybrid arrays
  - Sub LUN tiering
  - Caching
- Storage Network Caching
- Server side caching
- ServerSAN

Flash in the Server

- Minimizes latency and maximizes bandwidth
  - No SAN latency/congestion
  - Dedicated controller
- But servers are unreliable
  - Data on server SSD is captive
  - Good where applications are resilient
    - Web 2.0
    - SQL Server Always On
- Software cross-server mirroring
  - But that adds latency to writes

All Flash Array Vendors Want You to Think of This


But Some Are This
ENERGY
Gregory's


Or Worse This

Flash Memory SUMMIT

What You Really Want

Rackmount SSDs

- Our drag racers
  - They go fast but that's all they do
- The first generation of solid state
- Not arrays because:
  - Single Controller
  - Limited to no data services
  - IBM's Texas Memory
  - Astute Networks
  - Historically Violin Memory though that's changing

The Hot Rods

- Legacy architectures with SSD replacing HDD
  - NetApp EF550
  - EMC VNX-F
  - Equallogic PS6110s
  - Many 2nd and 3rd tier vendor's AFAs

- Limited performance
  - 50-300,000 IOPS
- Full set of data management features
- Wrong architecture/data layout for flash

All Solid State Arrays

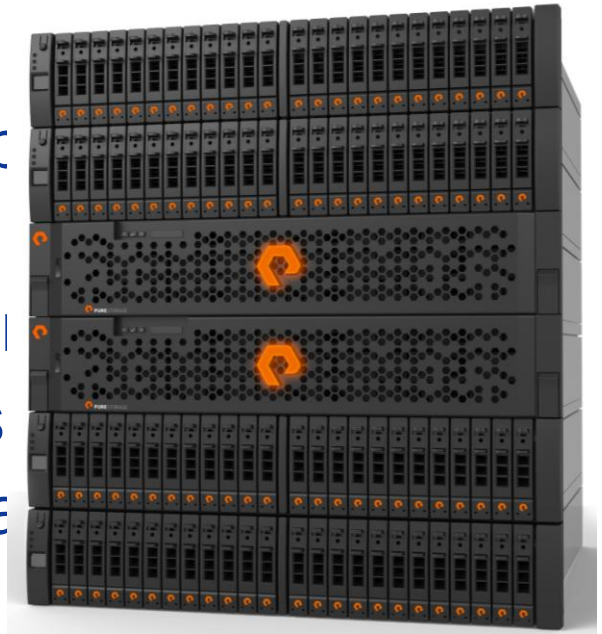
- Minimum dual controllers w/failover
- Even better scale-out
- Higher performance (1 megaIOP or better)
- Better scalability (100s of TB)
- Most have partial data management features
  - Snapshots, replication, thin provisioning, REST, Etc.
- May include data deduplication, compression
  - Lower cost w/minimal impact on performance

Legacy Vendors All Flash Array

- 3Par and Compellent's data layout better for flash
  - Easier tiering, less write amplification
- Dell - Compellent
  - Mixed flash
    - SLC write cache/buffer, MLC main storage
  - Traditional dual controller
- HP 3Par Storeserv 7450
  - 220TB (Raw)
  - 2-4 controllers

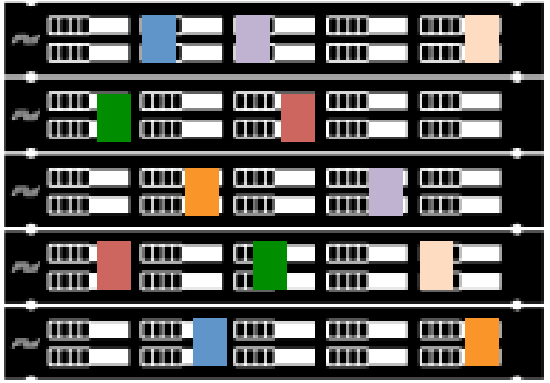
Pure Storage

- Dual Controllers w/SAS shelves
- SLC write cache in shelf
- 2.75-35TB raw capacity
- Always on compress and dedup
- FC, iSCSI or FCoE
- Snapshots now, replication soo
- Good support, upgrade policies
- Graduated from startup to upsta
- Promising scale-out



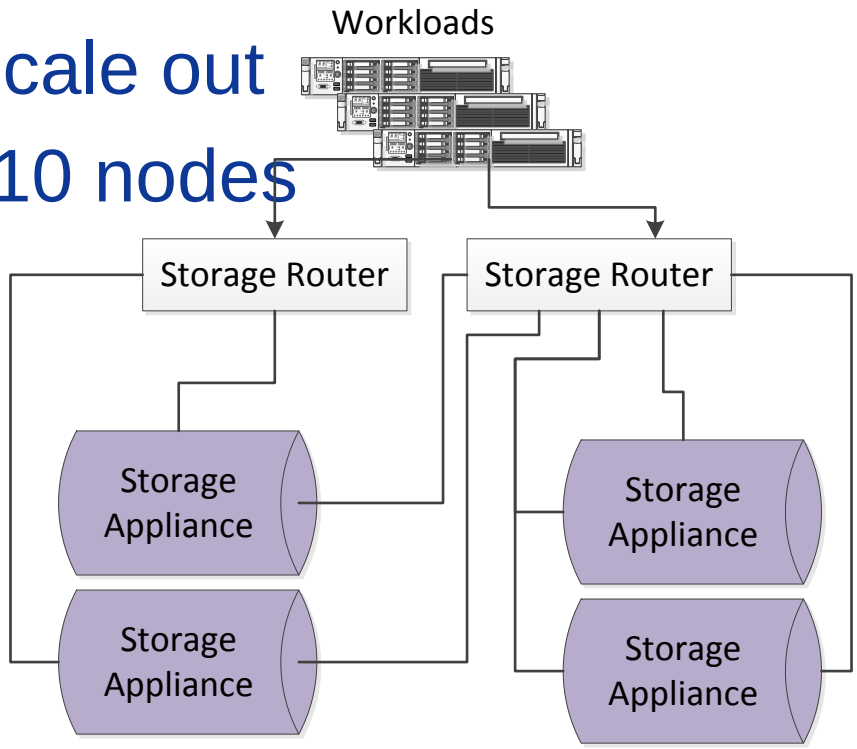
SolidFire

- Scale out architecture
  - 5 node starter 174TB (raw) 375K IOPS
  - Scale to 100 nodes
- Always on dedupe, compression
- Content addressed SSDs
- Leading storage QoS
- Moving from cloud providers to enterprise
- iSCSI, FC via bridge nodes



Cisco/Whiptail

- Cisco bought AFA startup Whiptail, put with UCS
- Storage router based scale out
- Up to 24TB raw node, 10 nodes
- FC, iSCSI
- Dedupe, compression



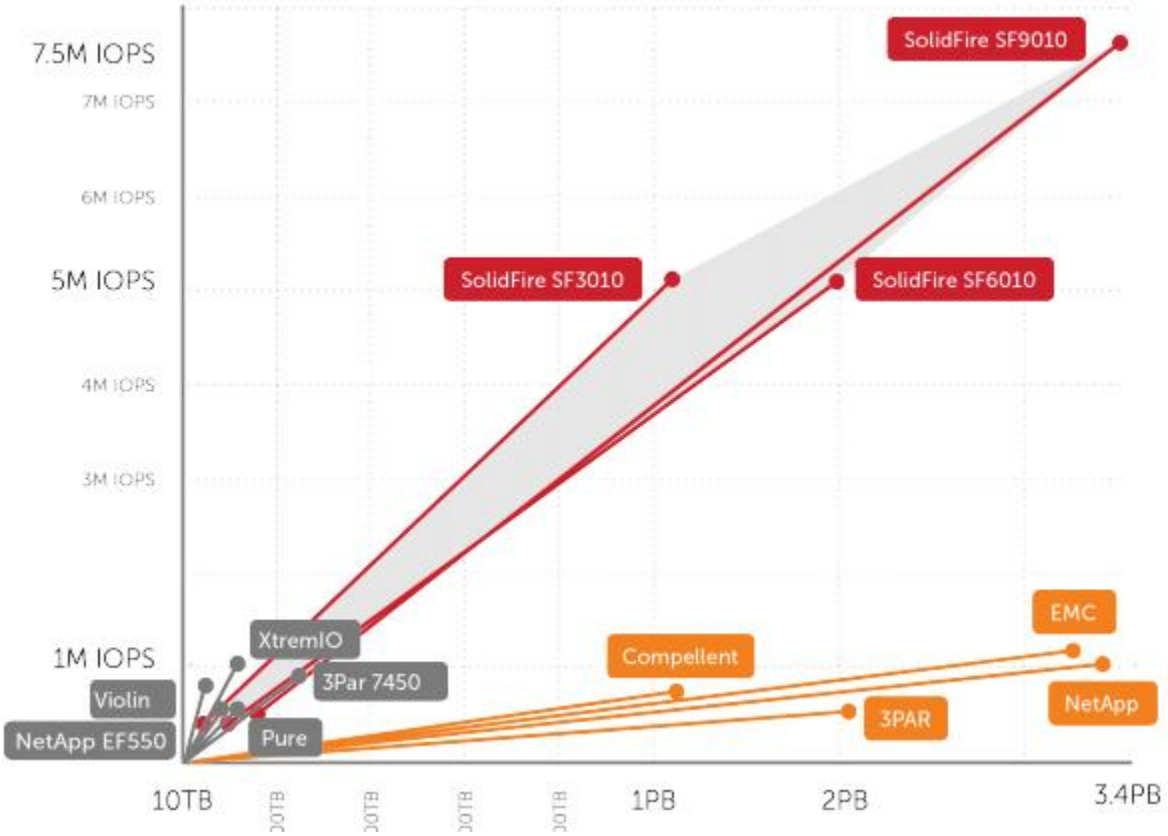
EMC XtremIO

- Scale-out Fibre Channel
- X-Brick is 2 x86 servers w/SSDs
- Scales to 8 X-Bricks (but not online)
- Infiniband RDMA interconnect
- Shared memory requires UPS
- Full time dedupe, CAS
- 10-80TB raw

Violin Adds Services

- Violin was market leader in hotrod era
- New management recognizes that's not enough
- Windows Flash Array - WSS on 6000 array
- Concerto 7000 storage routers ala Whiptail
  - Snapshots, replication Etc. via Falconstor
  - Scale to 280TB
- Unique flash modules
  - PCIe switched
  - Better consistency

All Flash Scaling

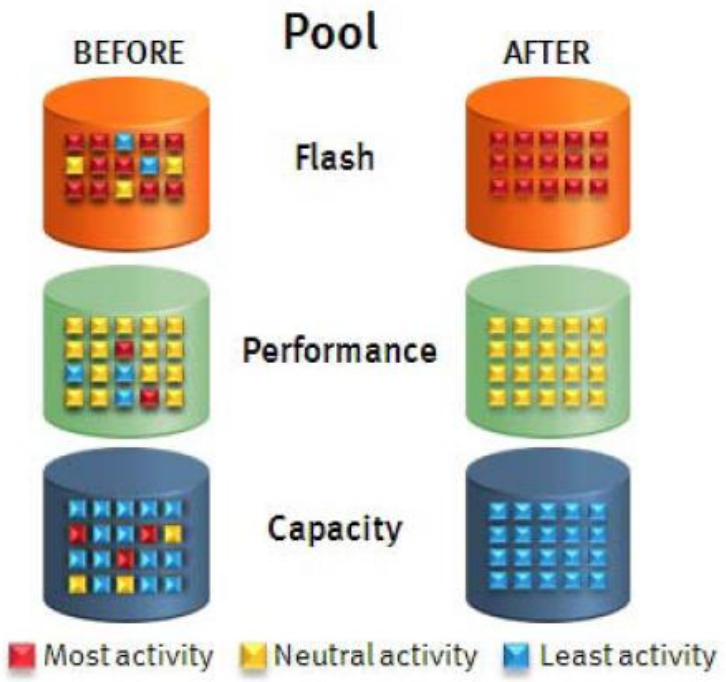


Hybrid Arrays

- Combine flash and spinning disk in one system
  - Usually 7200RPM
- Legacy designs with SSDs added
- Next-Gen Hybrids
  - Tegile
  - Nimble
  - Fusion-IO/IO control
  - Tintri
- High performance
  - 20,000 IOPS or more from 3-4u
  - 10% flash usually provides 2-4x performance boost
- Typically include deduplication, compression, virtualization features

Sub-LUN Tiering

- Moves “hot” data from slow to fast storage
- Only 1 copy of data
- Must collect access frequency metadata
- Usually on legacy arrays
- Ask about granularity, frequency
  - Up to 1GB, once a day
- Can give unpredictable performance

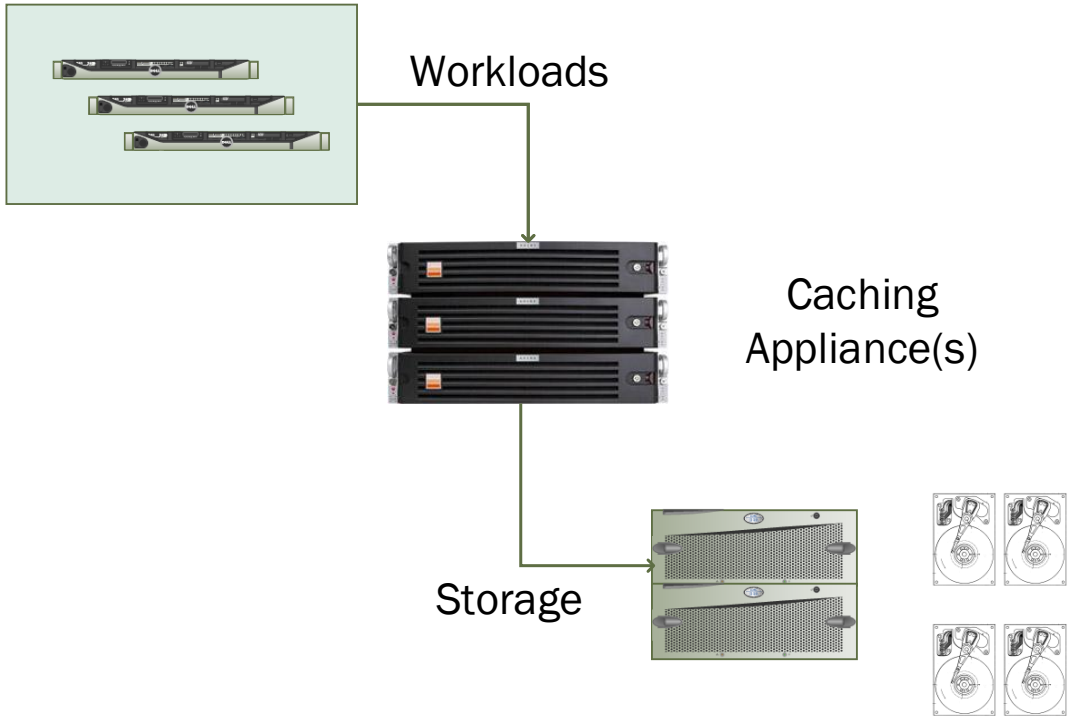


Flash Caching

- Data copied to flash on read and/or write
- Real time
- Write around
  - Reads cached
- Write-through cache
  - All writes to disk and flash synchronously
  - Acknowledgment from disk
- Write back cache
  - Write to flash, spool to disk asynchronously

Storage Network Caching

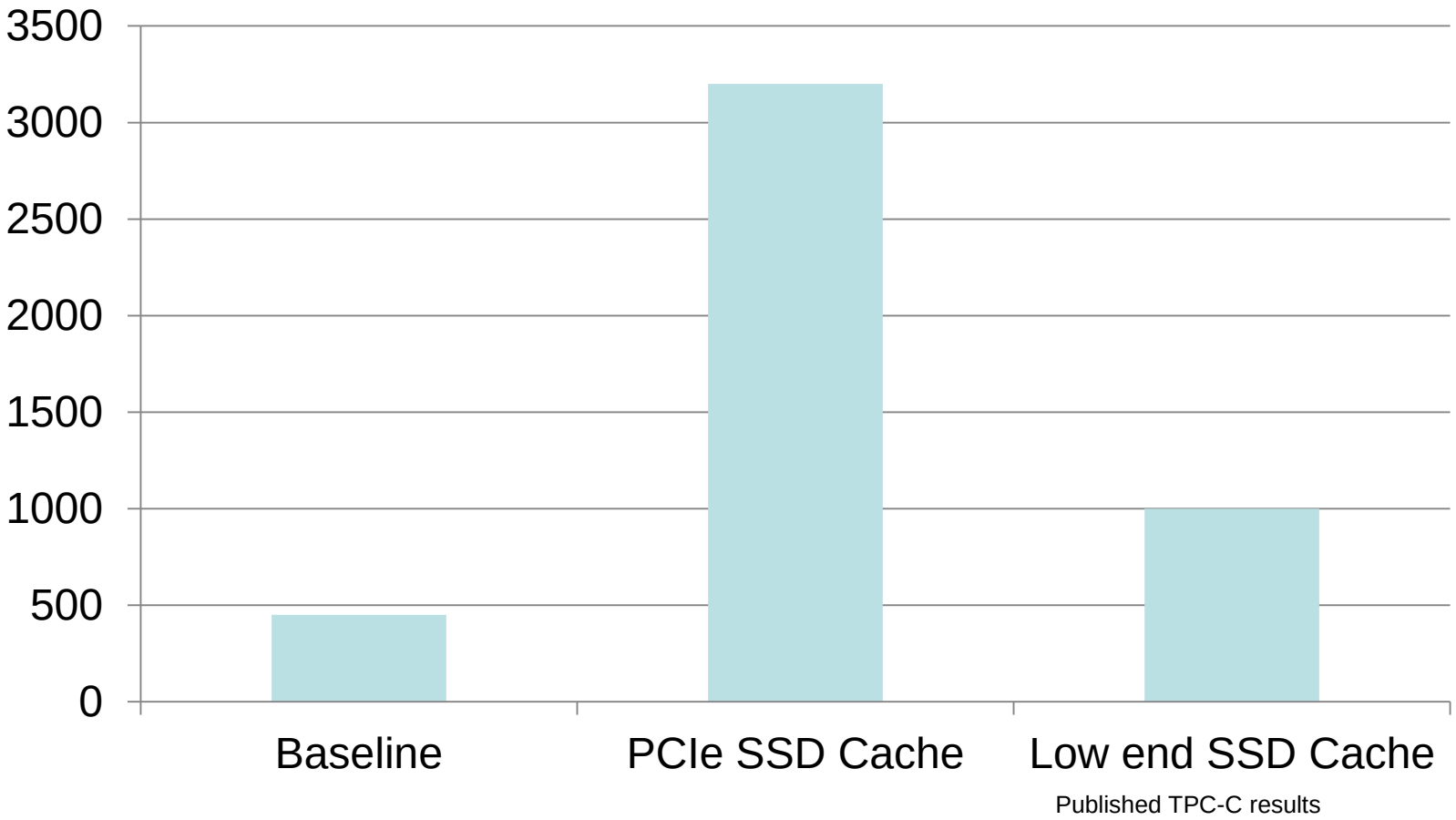
- Appliances available for:
  - Fibre Channel
    - Violin Maestro
      - Formerly: Gridiron Turbocharger
    - ~~DataRAM~~
  - NAS protocols
    - Avere
    - Alacritech
    - Netapp?
      - Bought CacheIQ
- Best over WAN



Server Flash Caching Advantages

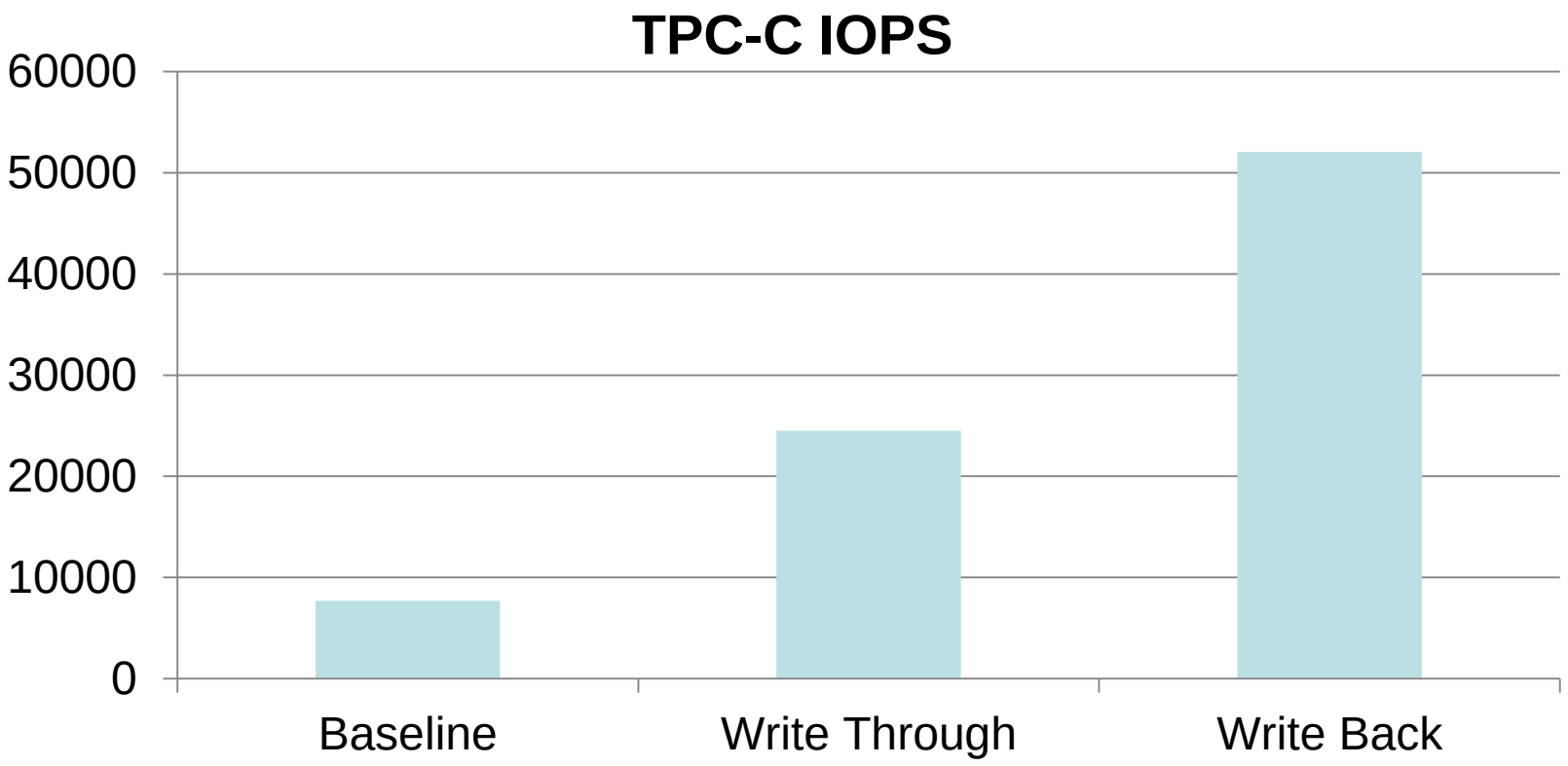
- Take advantage of lower latency
  - Especially w/PCIe flash card/SSD
- Data written to back end array
  - So not captive in failure scenario
- Works with any array
  - Or DAS for that matter
- Allows focused use of flash
  - Put your dollars just where needed
  - Match SSD performance to application
  - Politics: Server team not storage team solution

Caching Boosts Performance!



Published TPC-C results

Write Through and Write Back



- 100 GB cache
- Dataset 330GB grows to 450GB over 3 hour test

Server Side Caching Software

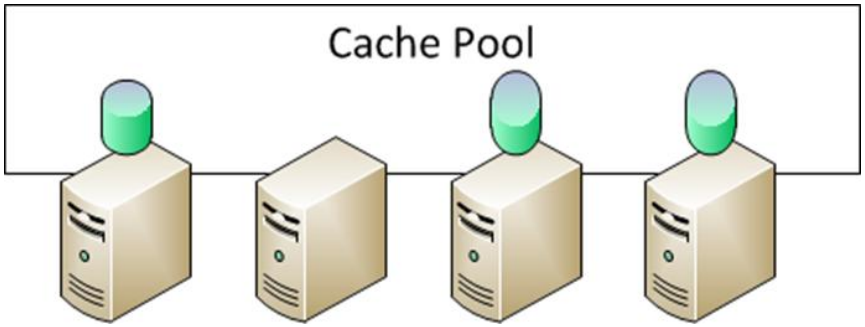
- Over 20 products on the market
- Some best for physical servers
  - Windows or Linux
- Others for hypervisors
  - Live migration/vMotion a problem
- Most provide write through cache
  - No unique data in server
  - Only accelerates
- Duplicated, distributed cache provides write back
- Applications cache too
  - SQL Server

Live Migration Issues

- Does cache allow migration
  - Through standard workflow
    - To allow automation like DRS?
- Is cache cold after migration?
- Cache coherency issues
- Guest cache
  - Cache LUN locks VM to server
    - Can automate but breaks workflow
- Hypervisor cache
  - Must prepare, warm cache at destination

Distributed Cache

- Duplicate cached writes across n servers
- Eliminates imprisoned data
- Allows cache for servers w/o SSD
- RDMA based solutions
  - PernixData
  - Dell Fluid Cache

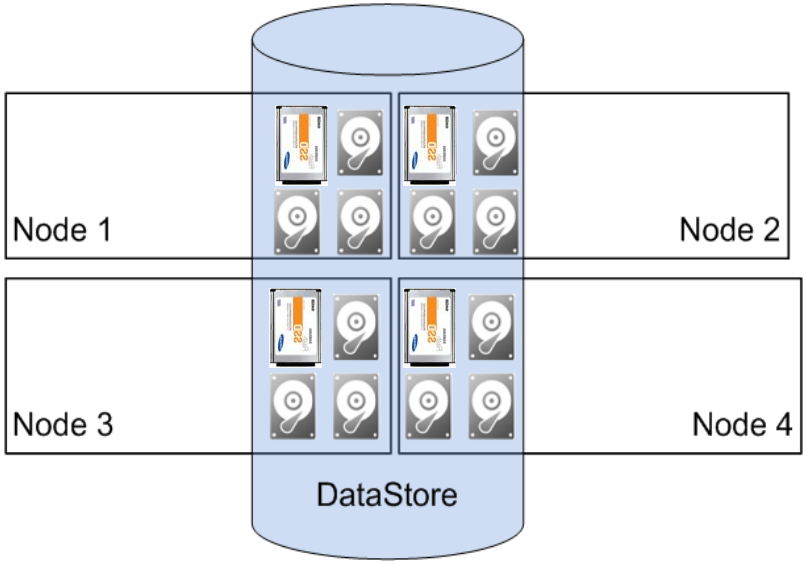


Virtual Storage Appliances

- Storage array software in a VM
- iSCSI or NFS back to host(s)
- Caching in software or RAID controller
- Players:
  - ~~VMware~~
  - StoreMagic
  - HP/Lefthand
  - Nexenta

Hyperconvirged Infrastructure (ServerSAN)

- Use server CPU and drive slots for storage
- Software pools SSD & HDD across multiple servers
- Data protection via n-way replication
- Can be sold as hardware or software
  - Software defined/driven



ServerSAN Products

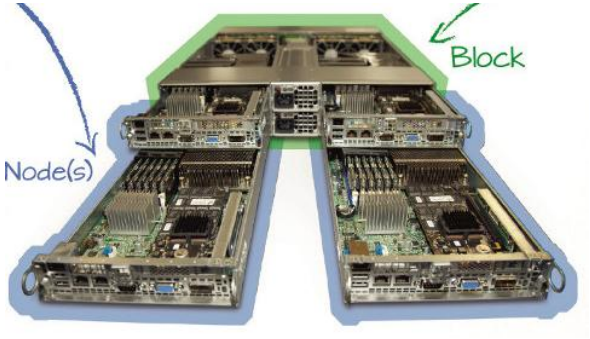
- VMware's VSAN
  - Scales from 4-32 nodes
  - 1 SSD, 1 HDD required per node
- Maxta Storage Platform
  - Data optimization (compress, dedupe)
  - Metadata based snapshots
- EMC ScaleIO
  - Scales to 100s of nodes
  - Hypervisor agnostic
- Atlantis Computing ILIO USX
  - Uses RAM and/or Flash for acceleration
  - Works with shared or local storage

ServerSAN Architecture Differentiators

- Data protection model
  - Per node RAID?
  - *N*-way replication
  - Network RAID?
- Flash usage:
  - Write through or write back cache
  - SubLUN tiering
- Prioritization/storage QoS
- Data locality
- Data reduction
- Snapshots and cloning

Hyper-convirged Systems

- Nutanix
  - Derived from Google File System
  - 4 nodes/block
  - Multi-hypervisor
  - Storage for cluster only
- Simplivity
  - Dedupe and backup to the cloud
  - Storage available to other servers
  - 2u Servers
- Both have compute and storage heavy models

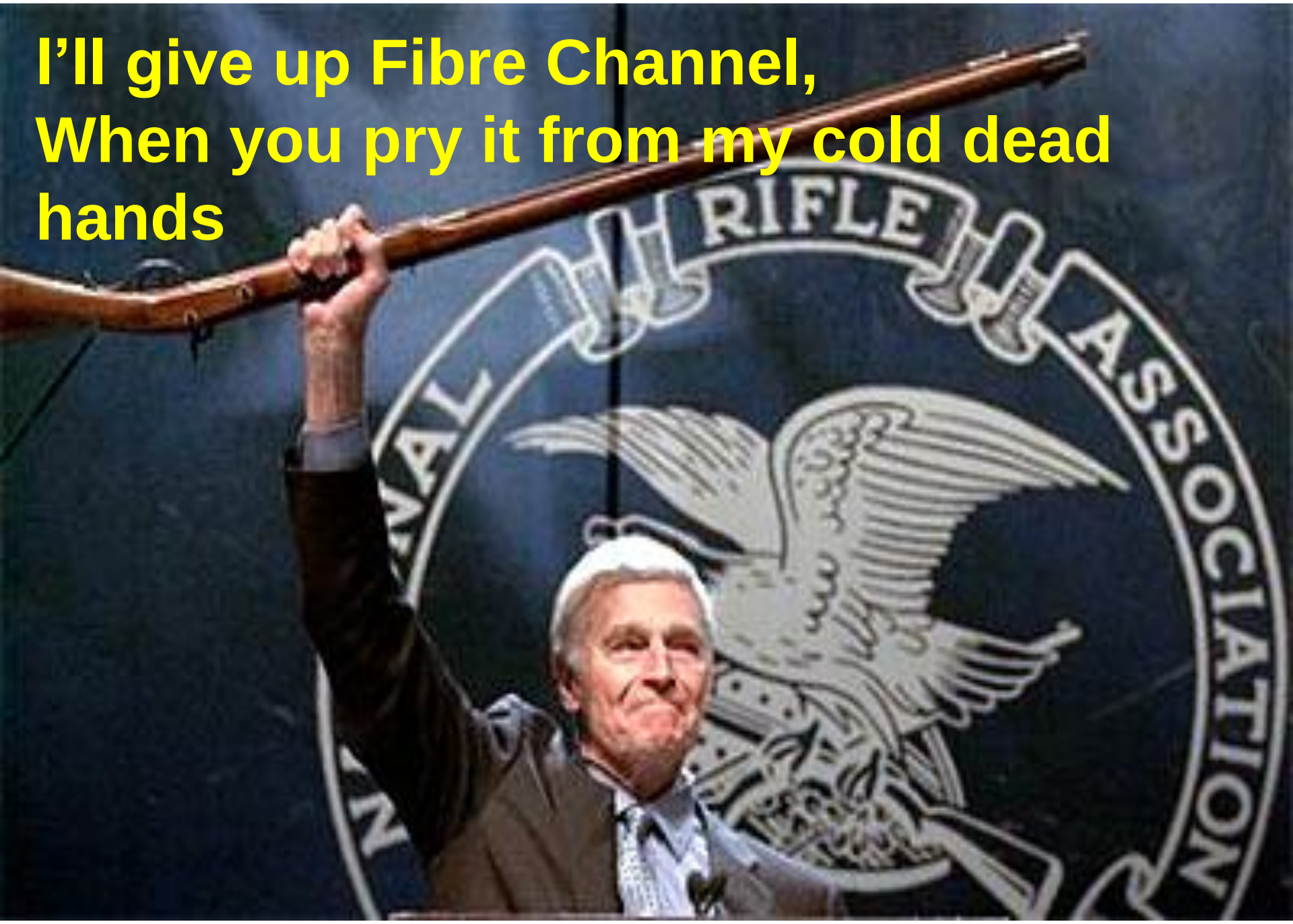


All Flash Array?

- If you need:
  - More than 75,000 IOPS
  - For one or more high ROI applications
- Expect to pay $4-7 GB
- Even with dedupe
- Think about data services
  - Snapshots, replication, Etc.

Hybrids

- Hybrids fit most users
  - High performance to flash
  - Low performance from disk
  - All automatic
- Look for flash-first architectures
  - Usually but not always from newer vendors
- Ask about granularity and frequency for tiering
- Again data services
  - Snaps on HDD
  - Per-VM services


I'll give up Fibre Channel,
When you pry it from my cold dead hands
RIFLE
ASSOCIATION

Server Side Caching

- Decouples performance from capacity
- Strategic use
  - Pernix data write back cache w/low cost array
- Tactical solution
  - Offload existing array
  - Boost performance with minimal Opex

Questions and Contact

- Contact info:
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  - @DeepStoragenet on Twitter