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Storage Intelligence

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Technology · Connections · Results

Tiering in Today's Disk Storage Systems

Session 09444

John Ticic
John Baker
IntelliMagic Inc.

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John's OK!

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Objectives

- Introduction
- Modern Storage Subsystem overview
- Hard Disk Drive overview
  - FC/SATA/SAS
  - SSD overview
  - HDD/SSD Service Times – utilization!
- Application Service Times
- I/O Profiles
  - R/W, Random Sequential
- Where will SSD’s help
- Roadblocks to success and Alternatives

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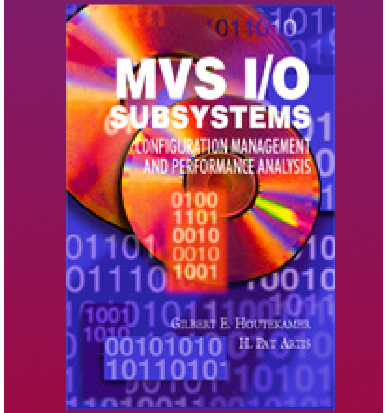

Who is IntelliMagic?

- The Storage Performance Company.
  - Since 1991 software solutions to hardware vendors.
  - Since 2005 to some of the largest end-user sites (small too!)
- Deep industry expertise: founder is Dr. Gilbert Houtekamer, MVS I/O Subsystems author (w/ Dr. P. Artis)
- Solutions:
  - IntelliMagic Vision, IntelliMagic Direction, IntelliMagic Balance
- Services:
  - 4 Day Class: z/OS Storage Performance & Architecture
  - Performance Diagnosis Study
  - Disk Subsystem Sizing & Configuration Study
  - Replication Bandwidth Analysis
  - Volume Migration Planning

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About Me

- 4 years as Performance Specialist with IntelliMagic
- 15 years of mainframe experience at a large international bank
- Responsibilities included:
  - Far too much SAS
  - “Bill”/WLM: pre and post Goal Mode
  - Set CPU weights and virtual storage parms
  - Online/batch tuning (1000+ online transactions/sec and 75000 batch jobs per day)
  - DASD tuning (VSAM buffering, striping, tune sort parms, manage and place ‘loved’ data)
  - Designed and implemented synchronous remote copy in production for all 13000 production volumes
  - According to IBM this was the largest GDPS in the world at the time
  - 100% availability of the Production Sysplex for over 10 years

Modern Storage Systems

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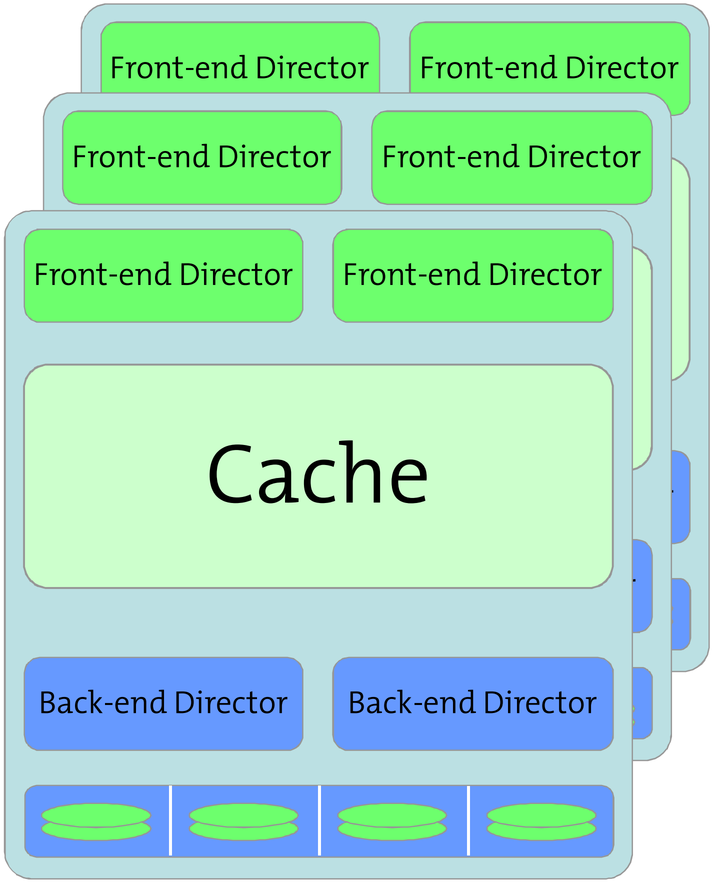
Disk Subsystem Architecture



- All vendors agree:
  - Front-end Controllers are specialized processors to connect to hosts or other subsystems (copy services)
  - Back-end Controllers are specialized processors to connect to disks
  - A large cache memory is required to provide good performance for reads and writes
  - A high-speed interconnect is essential (bus or switch)
- Two copies
  - Battery back-up & two copies are essential for all I/O to avoid that data written is lost
  - Provided in all enterprise class equipment

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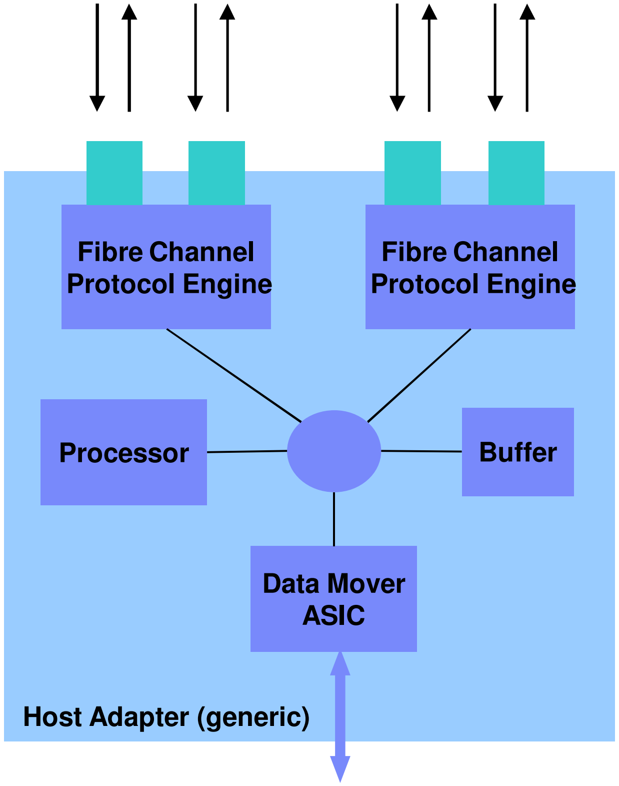
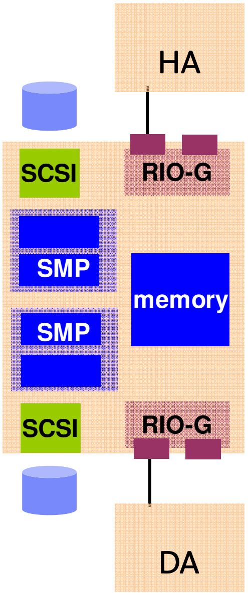
Front-end Director

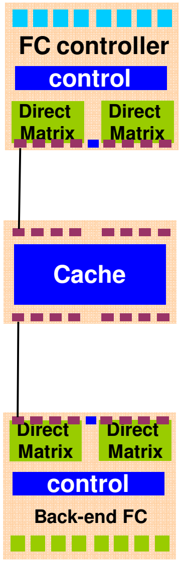


- Provides connectivity between disk subsystem and hosts
- Cards support ESCON, SCSI, FICON Fibre, SAS and/or iSCSI sometimes FICON and Fibre with one card
- Implementations differ greatly in maximum data handling capability, especially for FICON and Fibre
- Even though ports are rated as (e.g.) 4 Gbit/s, no implementation achieves this speed due to overhead.

Processors and Cache



IBM: centralized cache & NVS management

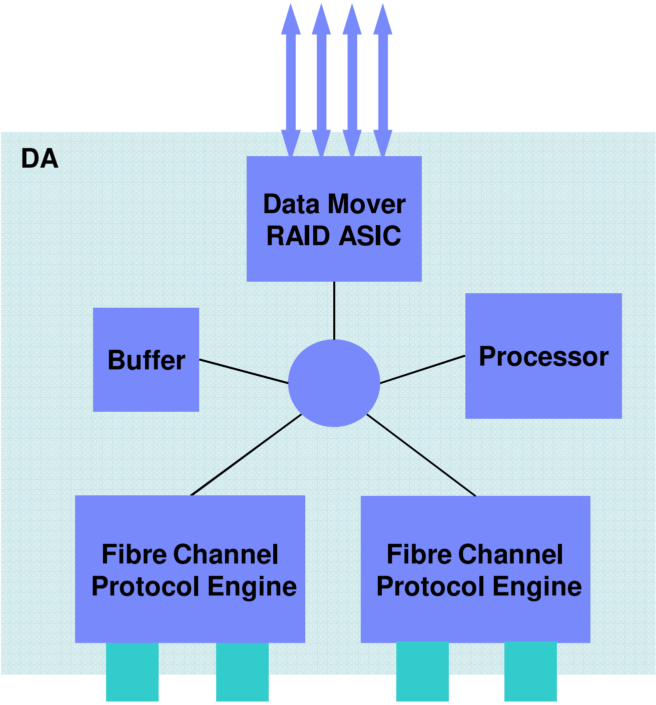


EMC/HDS: cache shared between engines

EMC: Fixed cache assignment

- Different implementations use different approaches
- All use cache to store
  - Recently used tracks and records
  - Recently written records
  - Pre-loaded tracks for sequential read
  - Some form of track descriptor tables to facilitate write operations without a disk access
  - Async copy information

Device Adapters



- Connect HDDs to internal Disk Subsystem resources
- Manage RAID operations, sometimes using cache memory for RAID computations
- Configured in pairs to provide redundancy if one adapter fails
- HDD interfaces include various generations of SCSI, SSA, FC-AL, SATA and SSD
- FC-AL switched back-end are gradually being replaced by SAS back-ends

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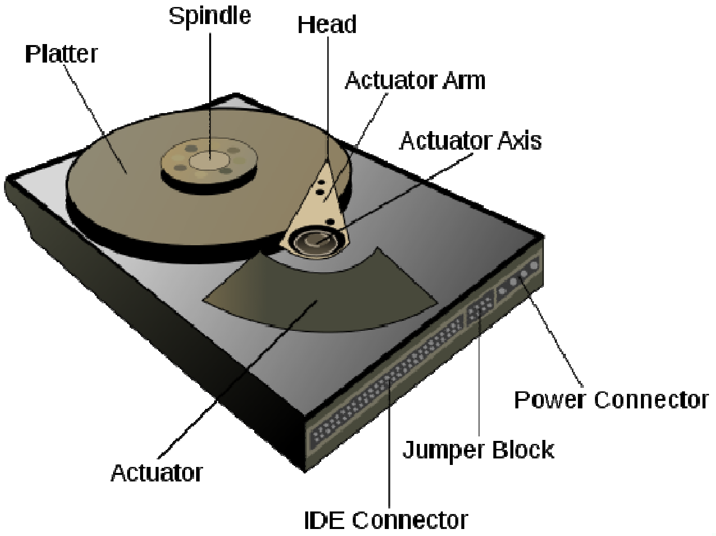
Drive Types

HDD

Access in milliseconds



Access in microseconds

SSD Flash is derived of byte addressable EEPROM

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Drive Protocols

Command sets commonly used:

- CKD CCWs for zSeries mainframe
  - Very elaborate command set
  - Designed around error detection and recovery
  - One command at a time per device address
- ATA for low-cost PC applications
  - Designed by Western Digital in 1986
  - One command at a time up through ATA-3
  - Write cache enabled but no battery back-up

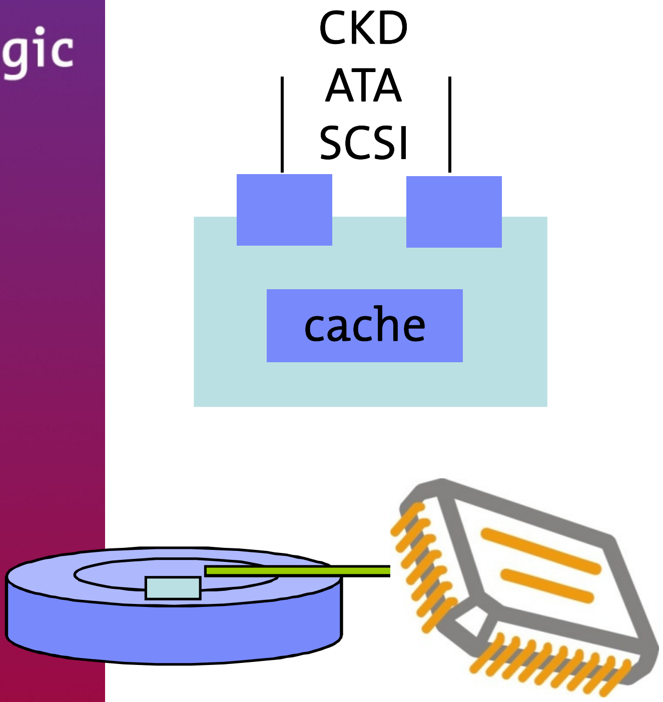
- SCSI for higher performance server applications
  - Based on Shugart Associated System Interface (1979) (SASI, Apple II)
  - Well defined command set
  - Tagged Command Queuing

Protocols and Connections

	ATA	SCSI	Wiring	Transfer Rate (MB/sec)
Serial	SATA	SAS: Serial Attached SCSI	Copper, serial	600**
Fibre Arbitrated Loop, Fibre	FATA	FC-AL, FC	Copper or Optical	800
Over TCP/IP	AoE (ATA over Ethernet)	iSCSI, FCoE	Ethernet	1000
'SSA'		SSA	Copper (Twister pair)	160

12G SAS: http://www.storagenewsletter.com/news/connection/lsi-sampling-12gb-sas-silicon

Drive Performance Characteristics



	HDD	SSD
Protocol: decode commands	Yes	Yes
Seek time: position head	Yes	N/A
Latency: wait for record to pass head	Yes	N/A
Data transfer	Yes	Yes
Sequential pre-load, caching	Yes	Yes
Optimize access	For speed	For wear

Latency: Rotational Delay

	RPM		Latency (ms)
	per min	per sec	
3390-3	4200	70	7.2
Older SATA	6000	100	5
SATA	7200	120	4.1
Most Fibre drives	10,000	167	3
High end Fibre drives	15,000	250	2
Solid State Drive	n/a		0

- Average delay is half a rotation

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Disk Service Times

	Protocol	Seek	Latency	Total
SATA	1?	9	4.1	14
10k RPM Fibre	0.3?	4.7	3	8
15k RPM Fibre	0.2?	3.6	2	5.8
10k RPM SAS	0.2?	2.6	3	5.8
SSD	0.2?	0	0	1

- Protocol time
  - Very small < 0.5 ms
- Average seek, assuming fully used HDD
  - Range 3.6 – 10 ms depending on technology
- Latency
  - Range 2 – 5 ms
- Data transfer for 512 bytes
  - Very small
- Total service time for read
  - From 0.2 to 15 ms

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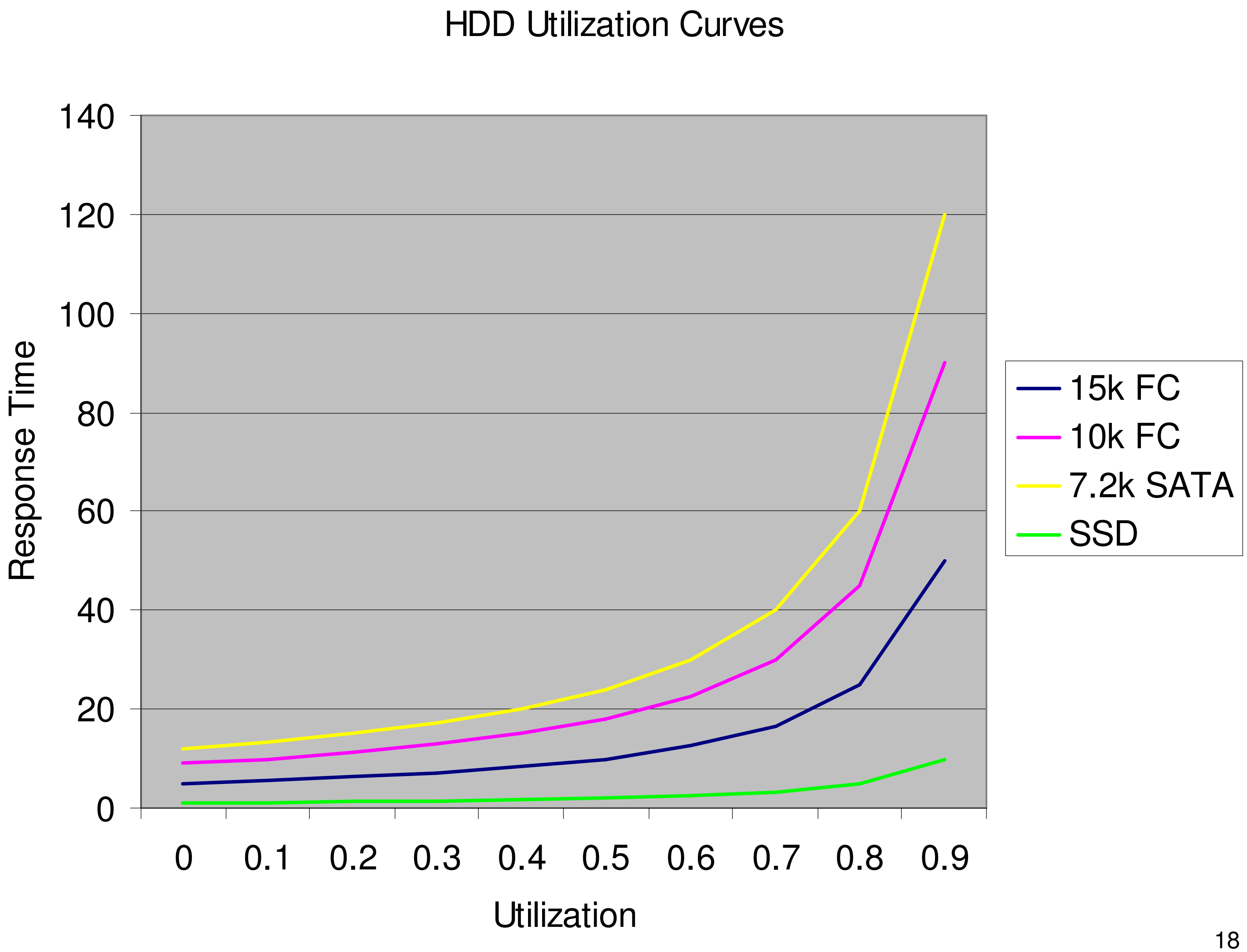
HDD Utilization Curve



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Application Service Times

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What is the user experience?

- Total Response time = CPU + I/O + Wait + Network
- CPU
  - Not fast enough – buy a 196!
  - Too many instructions – chase application people
- Wait
  - WLM priority?
  - Overcommitted resources (see #1)
- Network – always a great place to blame ☺
- Let’s break down our I/O time…

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I/O Response Components

- Response = IOSQ + Pending + Connect + Disconnect

- IOSQ
  - Wait for local device (UCB) busy

- Pending
  - Wait for channel, subsystem, or device in use by other LPAR

- Connect
- Time required to transfer data and commands to disk subsystem plus protocol overhead.

- Disconnect
  - Wait for information to be retrieved from disk (read), written to device (write) or to a secondary controller (copy services), or internal CU delays.

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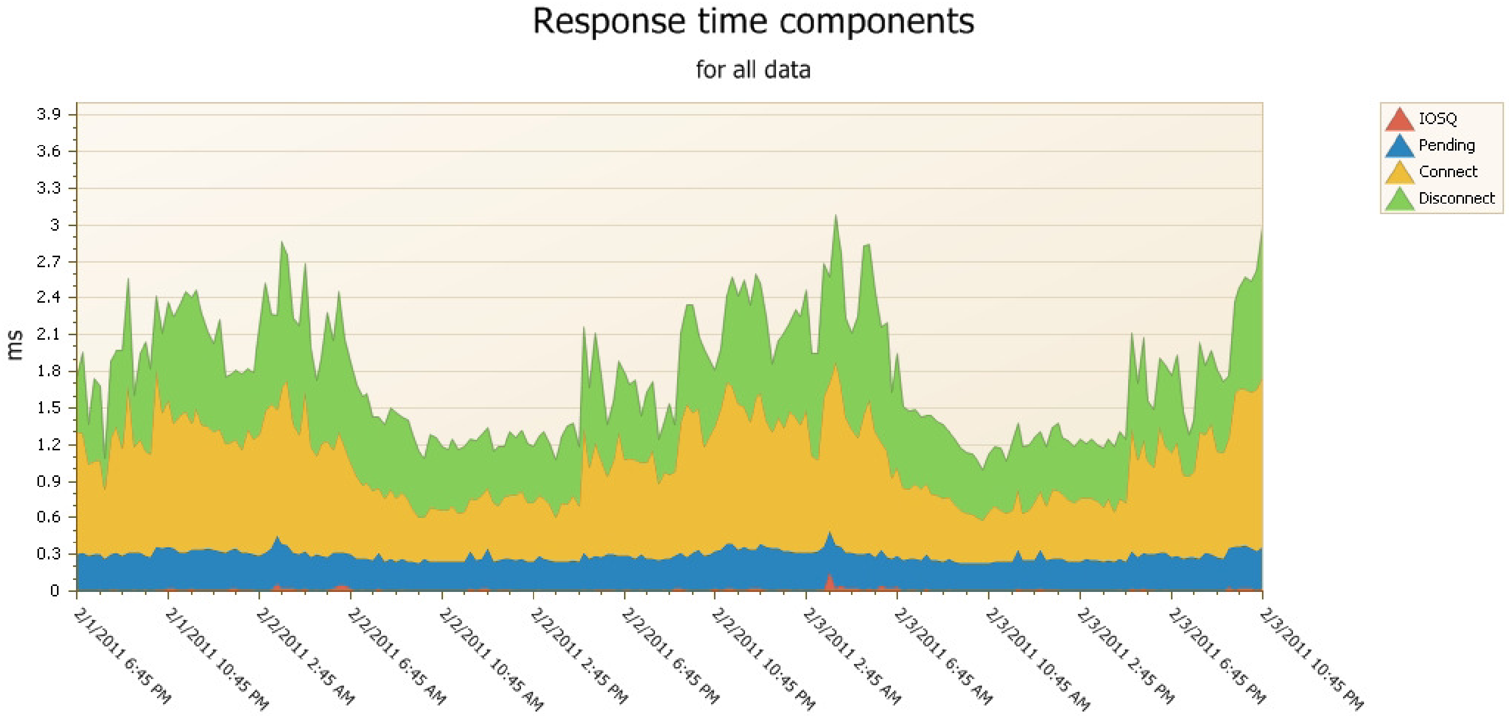
Where Will SSD's Help?



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I/O Profiles

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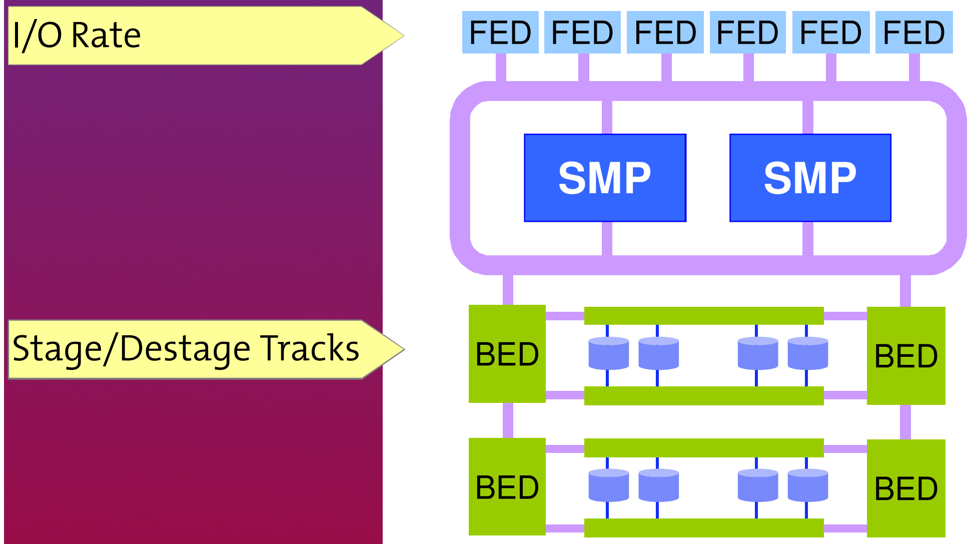
Backend Load Depends on Workload Characteristics



- **Random read hits** have no impact on backend
- **Random read misses** must be resolved by accessing a physical disk
  - Synchronous; service time matters
- **Random Writes** are cache hits, but must be written to the physical disks
  - Largest write overhead
  - Asynchronous
- **Sequential reads** are 100% cache hits, but, . . . need to access the physical disks for 100%
  - Asynchronous
- **Sequential writes** are 100% cache hits, but must be written to the physical disks
  - Can usually be optimized
  - Asynchronous

Questions you need to Answer

- Read/Write Ratio
- Cache hit %
- Sequential %
- RAID type
- Business Importance

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Hypothetical Scenario

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I/O’s per Transaction

- Let’s say a typical transaction requires 100 I/O’s
- Let’s take the average I/O response time of 2 ms from our chart
- But – only about .5 ms of that is Disconnect time

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What’s my Real Disconnect Time?

- RMF reports the average disconnect
- This does not mean that all I/O’s experienced disconnect
- The reality is that cache hits experience none (of significance)
- Disconnect time for misses can be calculated

What is the actual disconnect time for cache misses with an average disconnect of .5 ms and a hit ratio of 95%?

DISCm = RMFDISC / MISS RATIO

.5 / .05 = 10 ms

What does this mean for the actual response times of our I/O’s?

95% of the I/O’s experienced no Disc. While 5% experienced 10 ms (no I/O’s experienced .5 ms!)

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What if I was on SSD's?

- Potentially reduce 10 ms to <1 ms!
  - For 5% of I/O's
- 95% of I/O's are getting 1.5 ms response
- 5% are getting 2 ms
  - How to identify the candidates?

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The Road to SSD and Alternatives

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SSD Roadblocks

- $ per GB
  - SSD vs FC/SAS vs SATA
  - Should improve with competition
  - MLC!
- SSD's per DA… per DSS
  - Throughput limitations
- TB per DSS footprint
  - Floor space
  - Opposes desired consolidation
- Complex to implement efficiently

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Selecting SSD Candidates

- Loved ones
  - May be cache friendly = minimal benefit
- Auto tiering
  - Based on activity; may not be important to business
  - Analysis window and reaction time?
- SMF/RMF
  - Difficult and time consuming
- Software
  - Hardware Vendor, IBM, IntelliMagic

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Auto Tiering Options

- EMC FAST
  - Distributed systems: FAST for Virtual Pools (FAST VP) looks good
  - Very granular “chunk” size – 7.5 MB
  - Mainframe: Volume-level only
  - Three Tiers: Flash, FC (10K and 15K), SATA
- HDS HDT
  - Interesting “chunk” size of 42 MB
  - http://blog.nigelpoulton.com/thin-provisioning-the-mystical-42mb-allocation-unit/
  - Virtualization – good or bad?
  - Mainframe soon
- IBM EasyTier
  - 1 GB chunk size. Standard IBM “Extent” for many years
  - 2 Tiers (2 of SSD, FC/SAS, SATA)
  - Mainframe today

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MLC is coming!

- Original “Enterprise” SSD was only Single Level Cell (SLC)
- Can handle many more writes
- About 10x cost of Multi-Level Cell (MLC)

- IBM and Hitachi GST have certified MLC for enterprise use
- http://www.enterprisestorageforum.com/hardware/news/article.php/3917821/IBM-OEMs-STEC146s-MLC-SSDs.htm
- http://www.storagenewsletter.com/news/flash/hitachi-ultrastar-ssd400m

Alternatives

- Software Striping
  - SMS striping
  - Very Granular (track/CI)
  - Span DSS's (more channels = more throughput)
- Hardware Striping
  - Volume spanning RAID ranks
  - Chunk size may vary
- Balance!
  - Measure volume/rank activity
  - HDD response grows with disk utilization
  - ROT: stay under 50%
  - Use RMF or vendor tools

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Conclusions

- Back end HDD response is only one component of overall response and represents a very small portion of total I/O
- SSD = $$$ (MLC? = $)
- Controllers are not ready for wide-spread use
- Proper implementation is complex
- What is your current back end response?
- Are your users unhappy about response?

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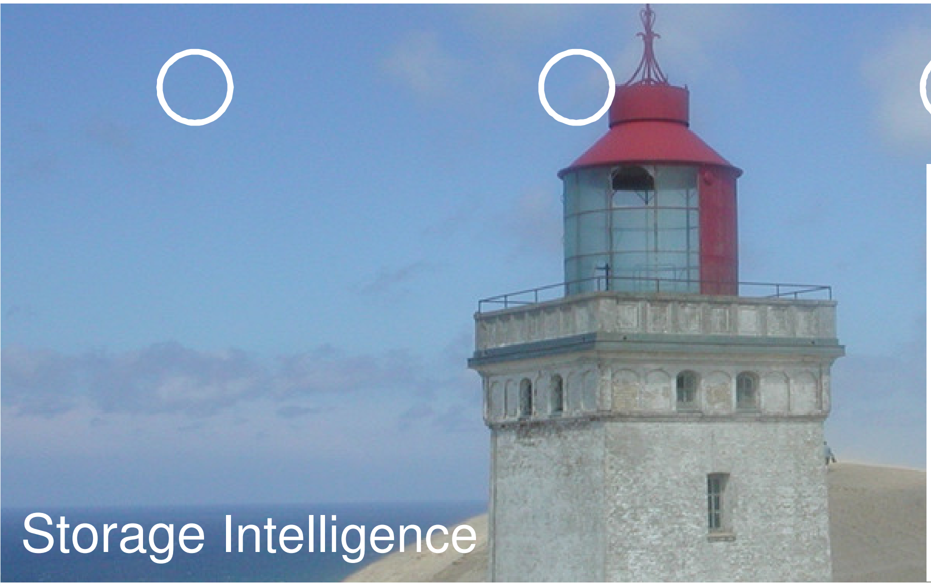

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Thank You

Questions?

John.Ticic@intellimagic.net

John.Baker@intellimagic.net