Session 3419:
ATA and Serial Attached SCSI

Levi Norman

Server Storage Marketing

Hewlett-Packard
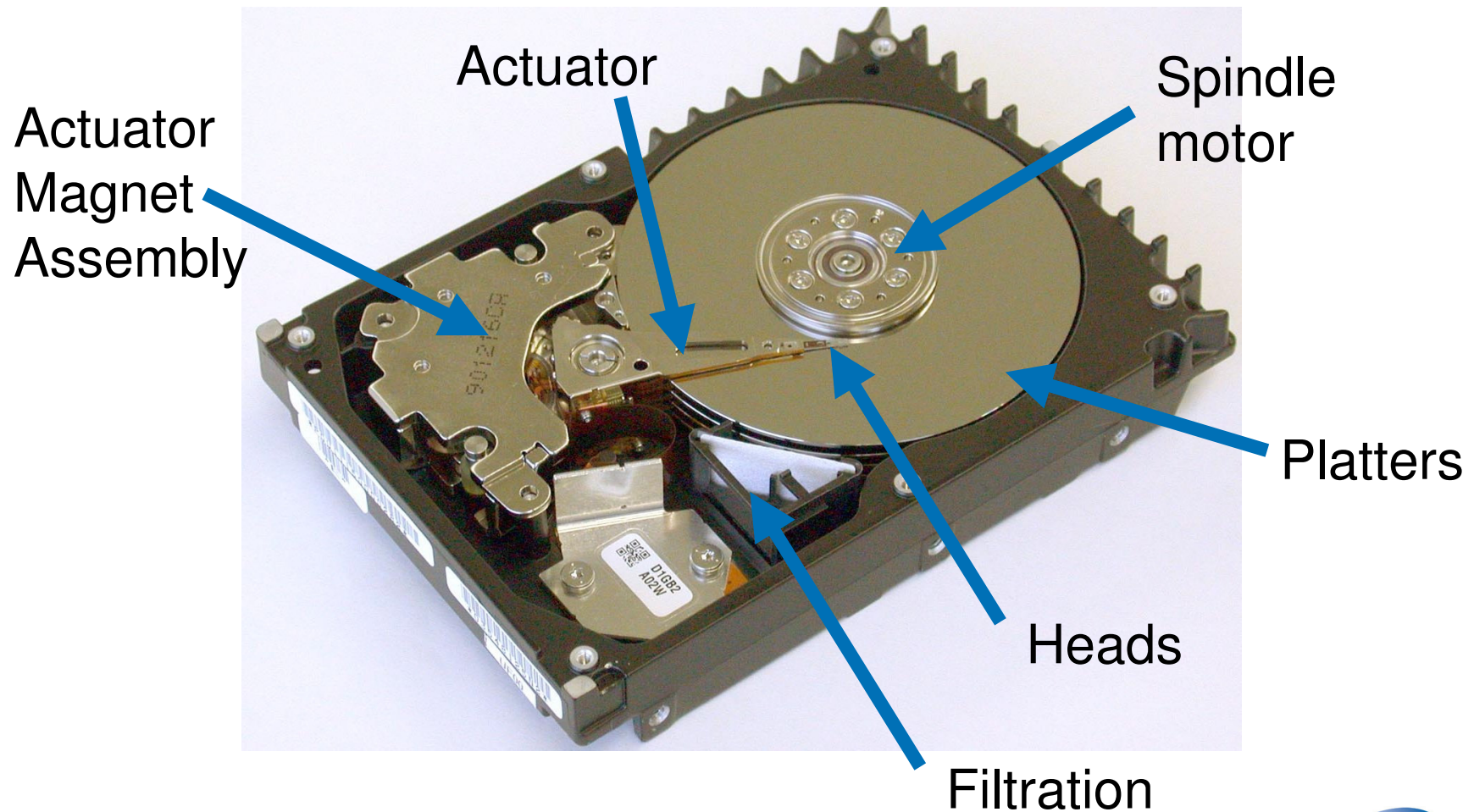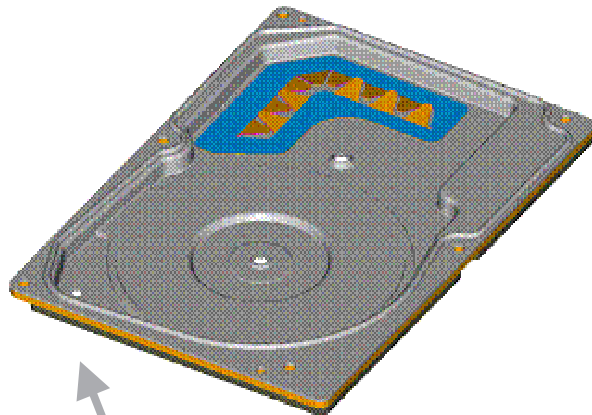
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Overview

- Enterprise and desktop drive design and features

- Parallel to Serial Transition

- Segmentation

Anatomy of a disk drive

Actuator

Spindle motor

Actuator Magnet Assembly

Platters

Heads

Filtration

Enterprise versus desktop devices

Robust Head Stack Assembly

- Rigidity to stay on track
- More heads
- Performs well in multi-drive environment

Smaller Diameter Disk

- Improves Seek
- Stable surface assuring reliability
- More platters

Performance Mechanics

- Larger magnets improve seek times
- Performs well in multi-drive environment
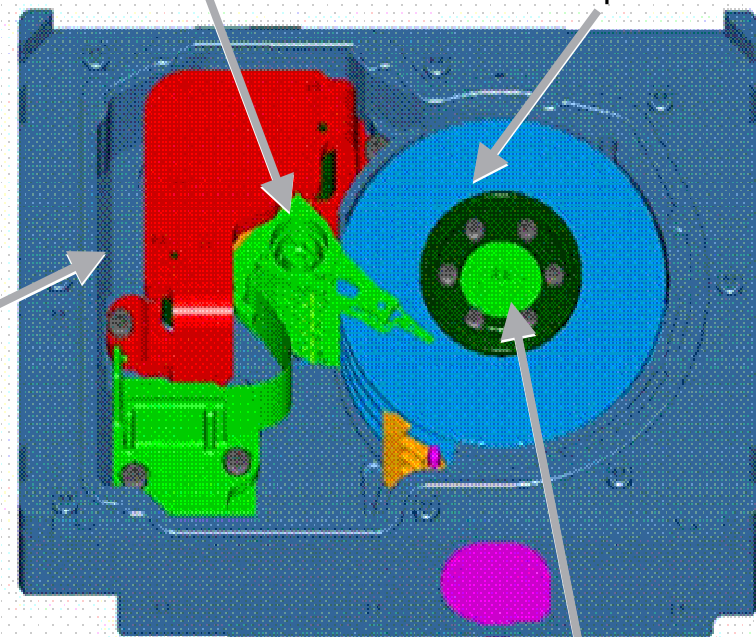- Stiff top cover minimizes susceptibility to Rotational Vibration

Motor

- Higher RPM
- Tighter Runout (variation)
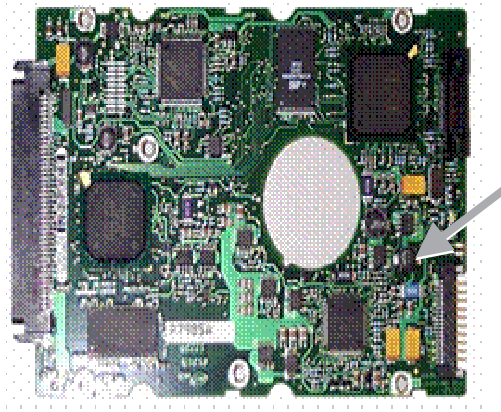
Electronics

- Components handle higher data rates
- Maximize performance via SCSI firmware
- Dual processors

Disk Drive Design Trade-offs

7200 RPM ATA/SATA HDD | **10K RPM SCSI/SAS/FC HDD** | **15K RPM SCSI/SAS/FC HDD**
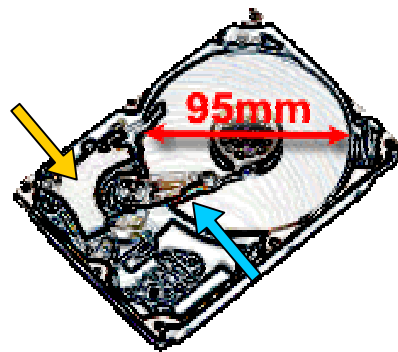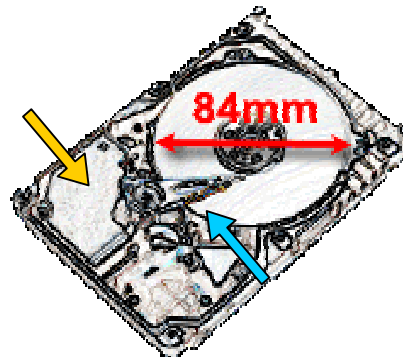
95mm   84mm   65mm
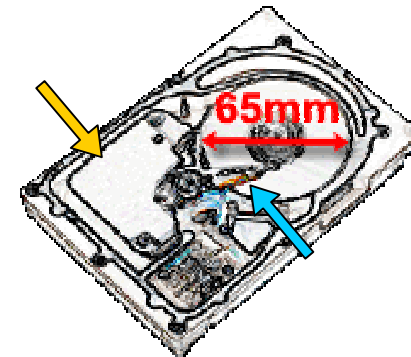
RPM
- The higher the RPM, the better the access times due to lower rotational latency
- The higher the RPM, the smaller the media size to minimize power consumption

Media Size
- Larger media provides greater capacity
- Larger media requires a lower maximum RPM to maintain rotational stability
- Larger media means longer seek times due to greater seek distances and smaller magnets

Actuator assembly
- The larger the actuator, the longer the seek time due to increased inertia

Actuator magnet
- The larger the magnet, the better the seek performance

Disk Parameter Comparisons

	Enterprise	Enterprise	Desktop
Form Factor	3.5"	2.5" (SFF)	3.5"
Interface	SCSI/FC/SAS	SCSI/FC/SAS	PATA/SATA
Spin RPM	15K / 10K	10K	7.2K
Capacity	36 – 300GB	36 – 73GB	40 – 250GB
Seek time	3.5ms / 4.7ms	<4.5ms	9.5ms
Random I/O	**~300 / ~220**	**~240**	**~70**
RVI rads^2	21	21	5
MTBF	**1.5M/hr** 24x7 100% duty	**1.5M/hr** 24x7 100% duty	**600K**/hr 8hr/d 20% duty
Error rate	1 in 10^16	1 in 10^16	1 in 10^15
Warranty	3 years	3 years	1 year

Have richard verify if desktop capacity needs to increase to 500GB

Hard Drives Features

Enterprise	Desktop
High IOP's	Low cost
High Availability	Capacity
Multi-user	Single User
Performance	Low Acoustics
Scalability	
High Temperature	
Manageability	
24x7 reliability	8-10hr/day reliability
100% duty cycle	20% duty cycle

Disk Drive Reliability

There is a significant difference in how MTBF is specified with respect to temperature, usage, and work load between **desktop** and **enterprise** disk drives

- Enterprise drives MTBF is based on 24 x 7 and continuous operation

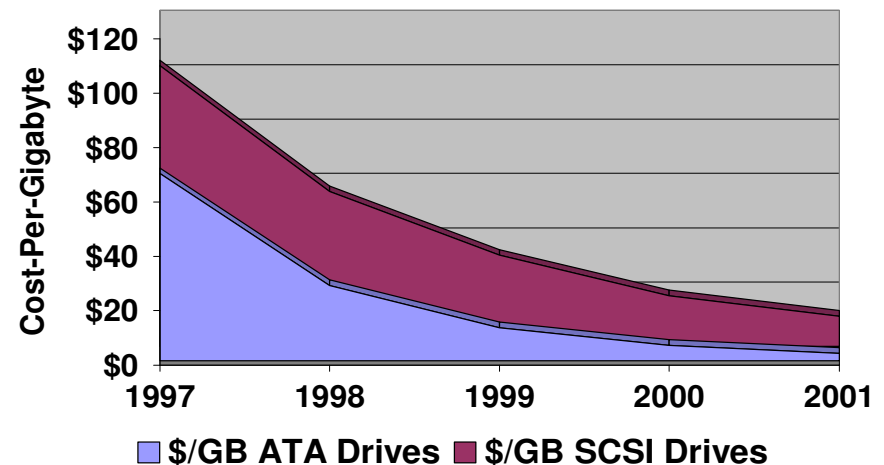- Desktop and Mobile are based on 8 hour per day use and low duty cycles
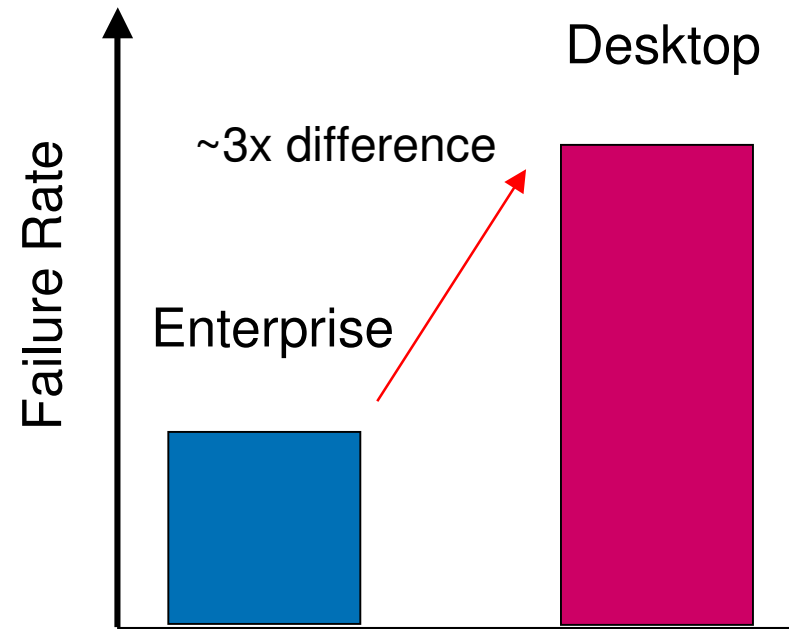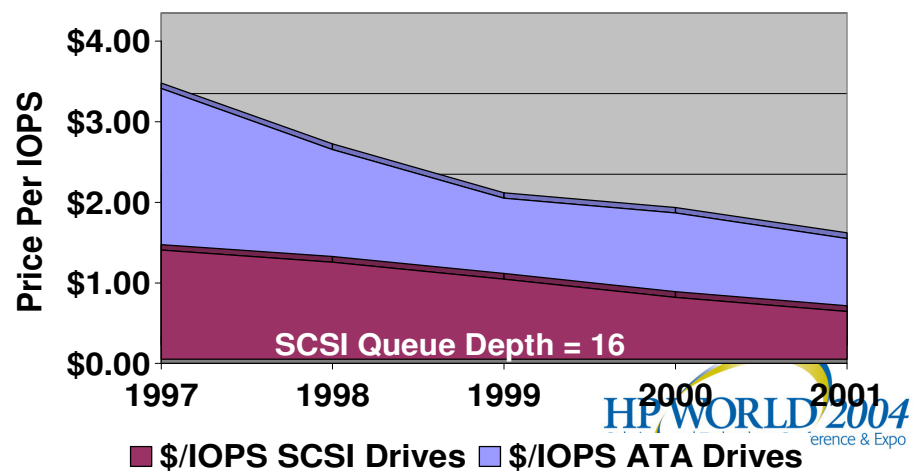

If used 8760 hours 100% duty cycle

Summary of disk differences

- **ATA drives are designed to meet the needs of PC and consumer applications**
  - These apps demand the lowest cost per gigabyte
  - Best $/GB trading off performance and reliability

- **SCSI drives are designed to meet the needs of mainstream servers, workstations, and RAID storage applications**
  - These apps require the lowest $ per IOPS and high availability
  - Best $/IOP, best multi user performance, with highest reliability

ATA Disks: Best Cost-Per-Gigabyte

Cost-Per-Gigabyte

$120
$100
$80
$60
$40
$20
$0

1997   1998   1999   2000   2001

☐ $/GB ATA Drives   ☐ $/GB SCSI Drives

SCSI Disks: Best Price-For-Performance

Price Per IOPS

$4.00
$3.00
$2.00
$1.00
$0.00

SCSI Queue Depth = 16

1997   1998   1999   2000   2001

☐ $/IOPS SCSI Drives   ☐ $/IOPS ATA Drives

Parallel to Serial Transition

enterprise

today: Fibre Channel

Parallel SCSI

tomorrow: SAS and small form factor HDD

Parallel ATA

today: SATA

desktop

2002   2003   2004   2005   2006   2007

SCSI Trade Association Roadmap

Parallel SCSI
Ultra 320

Serial Attached
SCSI
SAS 3Gb/s

Serial
Attached SCSI
SAS 6Gb/s

Serial Attached
SCSI
SAS 12Gb/s

U640 has been removed from the SCSI Trade Association road map.
U320 will be the last enhancement to the Parallel SCSI interface, followed by SAS.

2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012

What is Serial?

- Replacement parallel ATA and parallel SCSI
  - 100% SW compatible "drop-in"
- "Star" topology (point-to-point, no hubs)
  - Each device gets full bandwidth
  - No bus arbitration/collision overhead
- Serial ATA (SATA) and Serial Attached SCSI (SAS) have attributes and features that extend its capabilities
  - Provides additional capabilities such as hot plug and 1st party DMA
 - SAS provides for using SAS and SATA in the same box

Host/RAID Controller

HDD

HDD

HDD

Each host port connects to only one HDD

SATA connector drawing courtesy of Molex
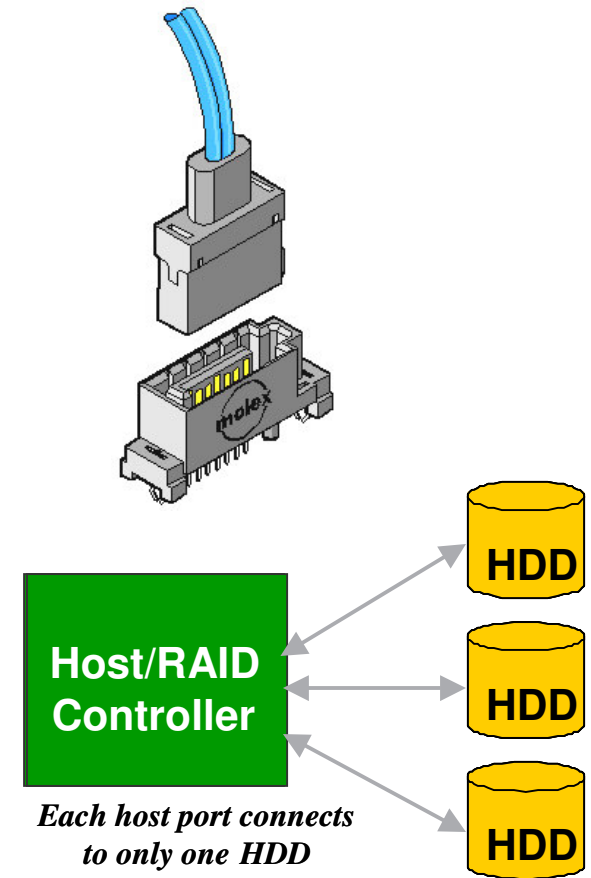
Serial Attached SCSI (SAS)
features and benefits

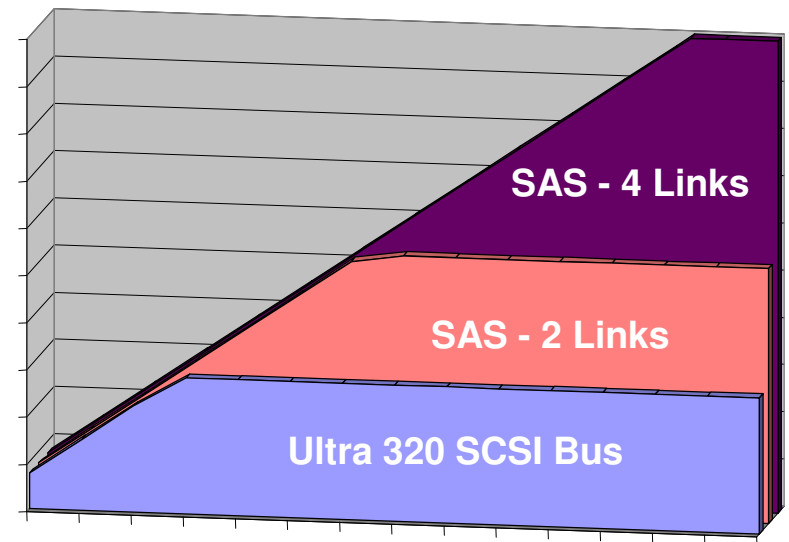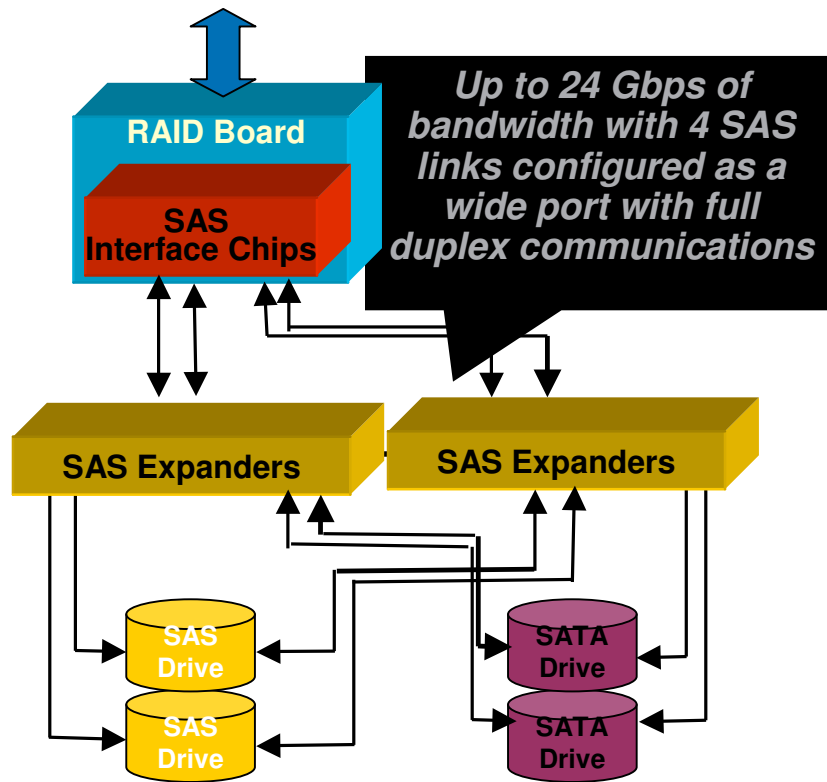| serial attached SCSI feature	serial attached SCSI benefit
thinner cable & fewer signals	improved chassis airflow & cooling resulting in easier cable routing for density faster HDD access times and improved IOPS
disk/backplane interoperability	customer flexibility and scalability simplifies IT support higher bandwidth per pin
leverages industry standards & current software stack	faster time to market and ease of transition improved interoperability performance
3 Gb/s (300MB/sec) performance	improved overall bandwidth growth roadmap to 6 Gb/s resulting in investment protection
smaller connectors	small form factor drives dual-ported hard disk drives
point to point topology	dedicated, scalable throughput resulting in improved IOPS support for 1096 devices
HDD failure indication	system uptime and reliability 50% improvement in MTBF to 1.5 million hours
cyclical redundancy checking	improved data integrity
LVD signaling	less cross talk and power

Serial Technology Enables Choice

One backplane accommodates either SAS or SATA HDDs
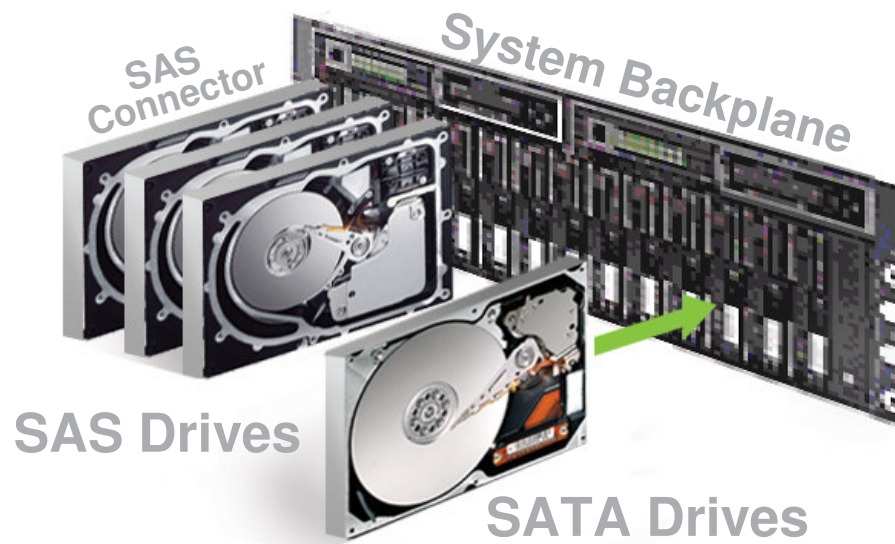
- High-performance & highly-reliable serial attached SCSI disk drives can be used for mission critical and performance-oriented applications
- High-capacity SATA drives can be used for disk enhanced backup or non-mission critical reference data

SAS Delivers Scalable Performance

RAID Board

SAS Interface Chips

Up to 24 Gbps of bandwidth with 4 SAS links configured as a wide port with full duplex communications

SAS Expanders

SAS Expanders

SAS Drive

SAS Drive

SATA Drive

SATA Drive

SAS - 4 Links

SAS - 2 Links

Ultra 320 SCSI Bus

- Four link, SAS controller provides scalable back-end bandwidth for up to 24Gbps data transfers with full duplex communications.

- Point-To-Point connections eliminate the shared bus bottleneck.

  – Bandwidth aggregated over multiple, low-cost Serial Attached SCSI links

  – Rate matching supports 1.5Gbs SATA and 3.0Gbs SAS drives for optimal performance

Summary Parallel to Serial Transition

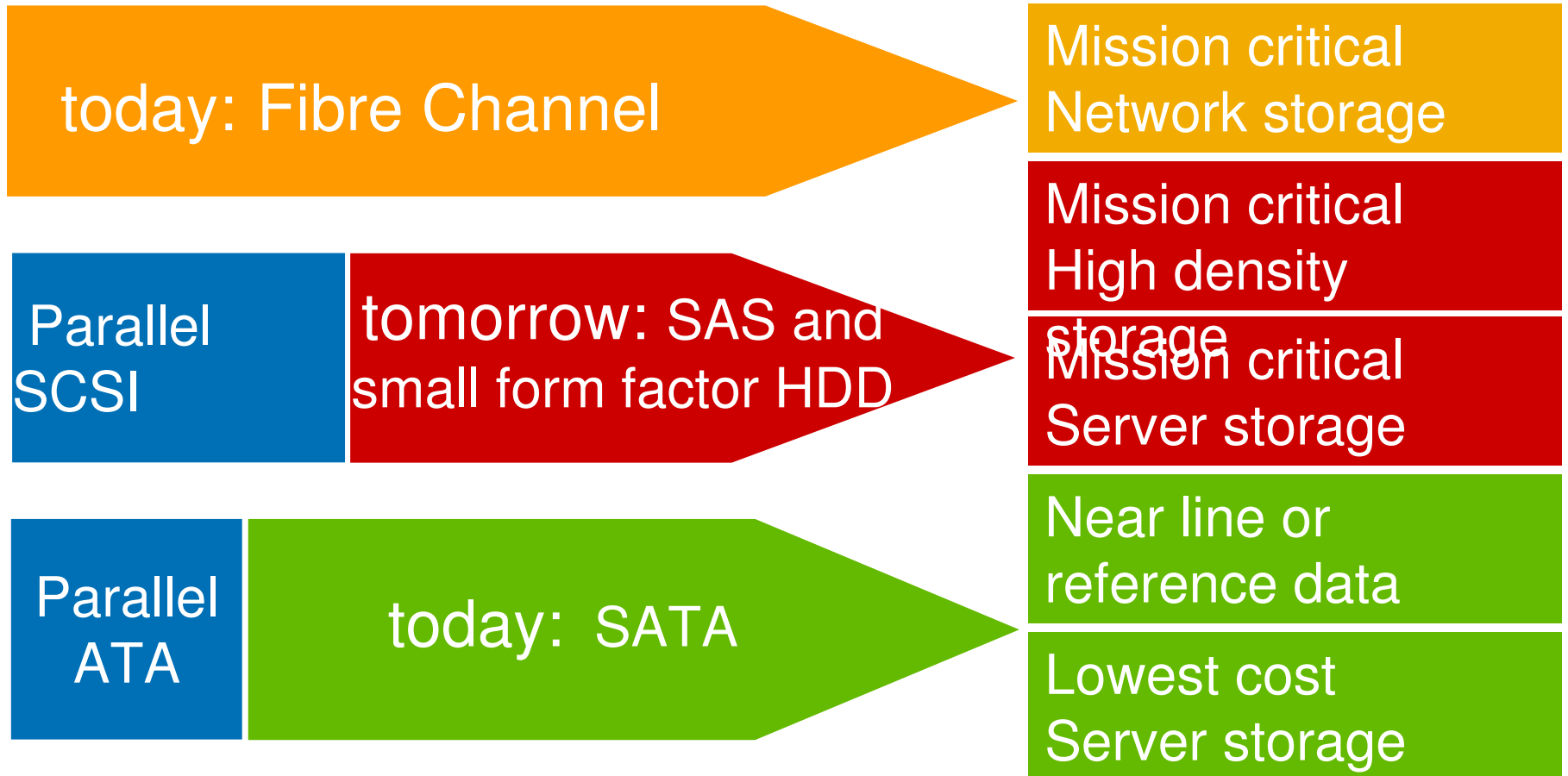| What's the Same	What's New

Builds off the SCSI protocol
    no new drivers
    same software
SATA is entry level
SCSI is enterprise level
SATA is 8 to 10 hours, 5 days a week
SCSI is 24x7x365
	Point-to-point
	    dedicated bandwidth
	    between controller
	    and HDD
	Smaller, thinner cables for better
	    airflow and cooling
	Greater flexibility
	    mix SATA and SAS
	    on same backplane
	Ability to connect more devices

Datacenter storage segmenting

today: Fibre Channel

Mission critical
Network storage

Parallel SCSI

tomorrow: SAS and small form factor HDD

Mission critical
High density
storage

Mission critical
Server storage

Parallel ATA

today: SATA

Near line or
reference data

Lowest cost
Server storage

HDD Market Segmentation

Networked Server High Density Storage	Mission Critical Storage
Critical To Customers	• Transactional Performance • Guaranteed Availability • Mission Critical Reliability
Driving Metrics	• IOPS per GB (Performance/Cap.) • IOPS per U (Performance Density)
Platforms For Products	FC, SAS, SCSI 10K - 15K RPM Access time: < 5.7ms Duty Cycle: 24 x 7x 365

Access time – is it average seek 3.5 to 4.5 ms; access time 5.5 to 5.7

HDD Market Segmentation

Near-line or Reference data Low Cost Server	Non-mission Critical Enterprise
Critical To Customers	• Sequential Performance • High Capacity • 9-5, 5 days a week reliability
Driving Metrics	• $ per GB (TB solutions) • $ per GB (Small Capacities; Cost)
Platforms For Products	Near-line or Reference data & Low Cost Server SATA, ATA 7.2K RPM Access time: < 13ms Duty Cycle: 8 to 10 hours, 5 days a week

Technology Comparison

	SATA	SAS	Fibre Channel Arbitrated Loop
Performance	Half-duplex	Full-duplex with Link Aggregation	Full Duplex
	1.5 Gb/s Introduction 3.0 Gb/s in 2004	3.0 Gb/s Introduction 6.0 Gb/s in 2006	2.0 Gb/s 4 Gb/s in 2005
Connectivity	1.5 m internal cable > 8 m external cable	> 8 m internal and external cables	15 m external cable
	One device (fan-out devices demonstrated)	>128 devices (16,384 max)	127 devices
	No peer-to-peer	Peer-to-peer	Peer-to-peer
Availability	Single-port HDDs	Dual-port HDDs	Dual-port HDDs
	Single-host	Multi-initiator	Multi-initiator
Driver Model	Software transparent with Parallel ATA	Software transparent with Parallel SCSI	Software transparent with Parallel SCSI

Drive Usage Summary

	SATA	SAS
Drive Strengths	Capacity	Reliability
	Lowest Cost Per GB	Best Price for Performance
Applications	Reference Data	Transactional Data
	Non-Mission Critical Applications (near-line storage, data tubs)	Mission Critical Applications (on-line transactions, banking)
	Entry level servers and bulk storage	Main stream servers and storage
Reliability	Desktop Class Architecture	Enterprise Class Architecture
	8 to 10 hours, 5 days a week 20% Duty Cycle	24x7x365 100% Duty Cycle

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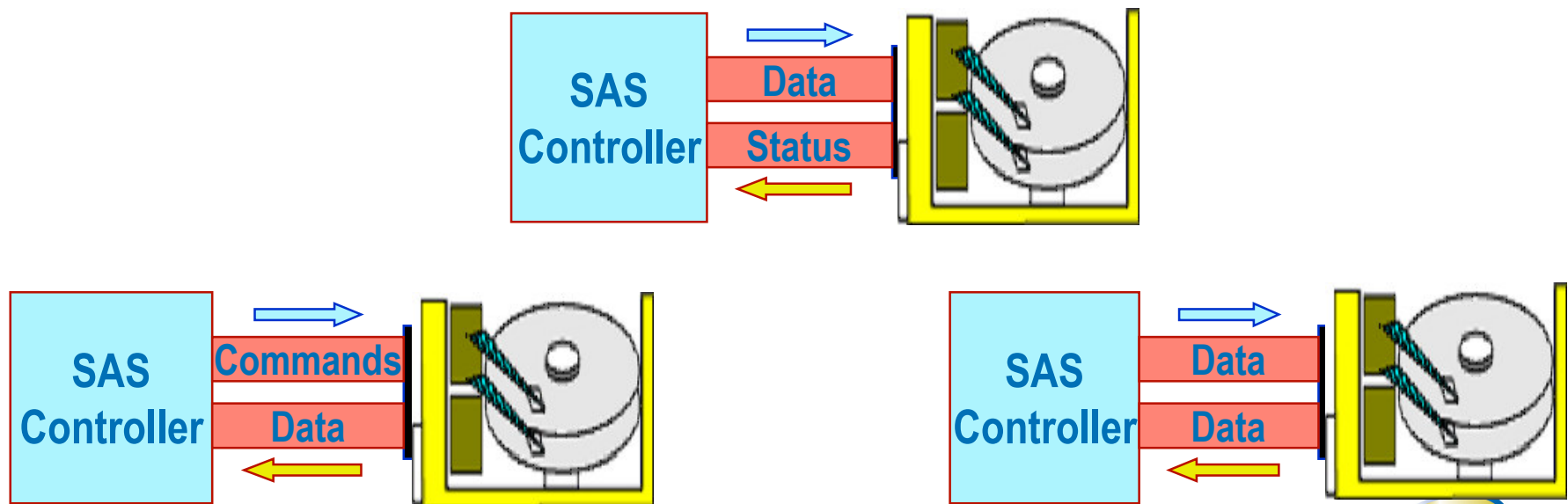
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What is full duplex?

- The SAS interface allows for communication in both directions on a link simultaneously.

- SAS will ship full duplex first generation.

What is dual port?

- The SAS interface allows for devices to have two limited full duplex links. (Limited to no more that two simultaneous data transfers.)

- Second generation SAS devices are targeted as dual ported.

- Controllers can have (n) number duplex links.
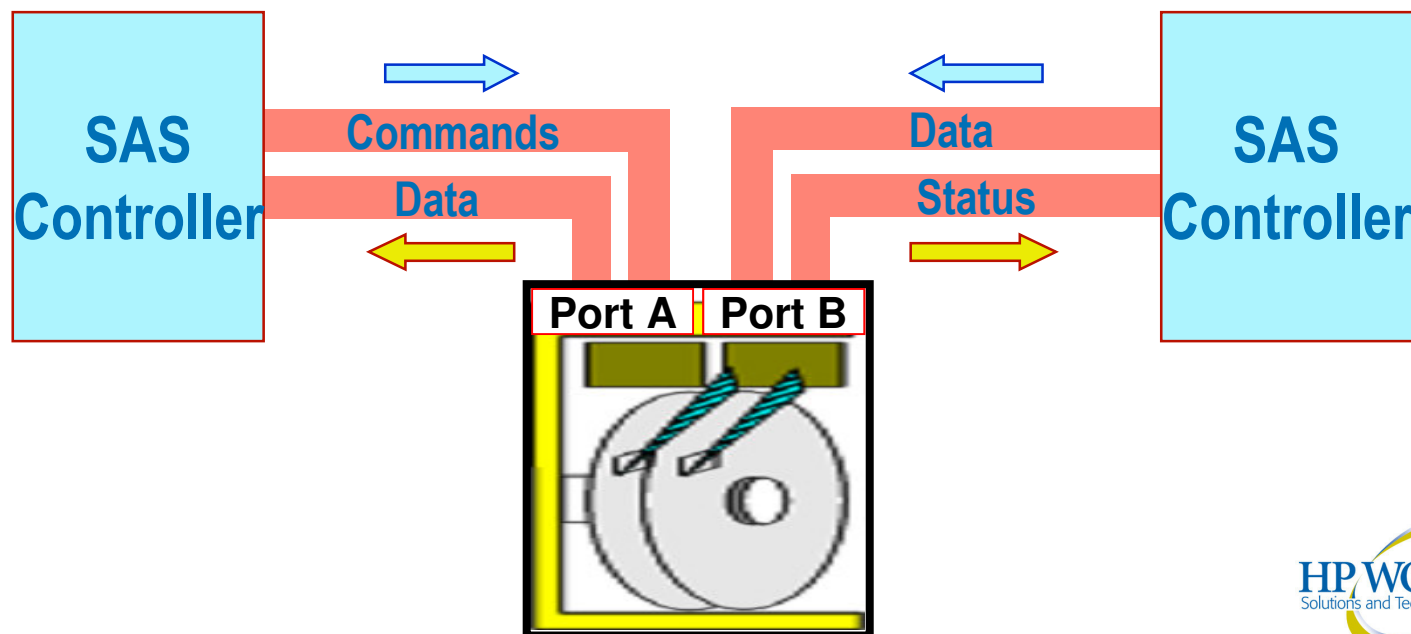
What are multiple links?

- The SAS interface allows for ganging of multiple ports together to create "wide" links. Wide links provide increased bandwidth 1x, 2x, 3x, 4x, of 300MB/s!

SAS Controller

Each link 300MB/s

1200MB/s Full duplex!

Expander