More than an interface - SCSI vs ATA

A paper review

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Introduction

Personal Storage (PS)	Enterprise Storage (ES)
HDDs for personal computers	HDDs for enterprises
Single user	Multiple simultaneous users
Home use	Strong reliability - business critical
Cost is deciding factor	Performance is deciding factor
Used alone	Used in groups

Functional Requirements

Seek performance

- Faster head movement
- Done by better actuators, larger magnets, vibration resilience

Rotational latency

- Make platter spin faster
- Innovations trickle down from ES to PS

Aggregration

- ES drives used in groups $\rightarrow$ More external vibration
- Redundant paths from host to HDD
- ATA supports atmost 2 HDD's
- SCSI controllers support more than 2 HDD's.

Advantages of SCSI

- *IDE* - Programmed I/O, *SCSI* - external controller chip
- Command queue processing
- Multiple CPU support
- Variable block size $\rightarrow$ EDP
- Dual porting $\rightarrow$ controller failover

Tech differences

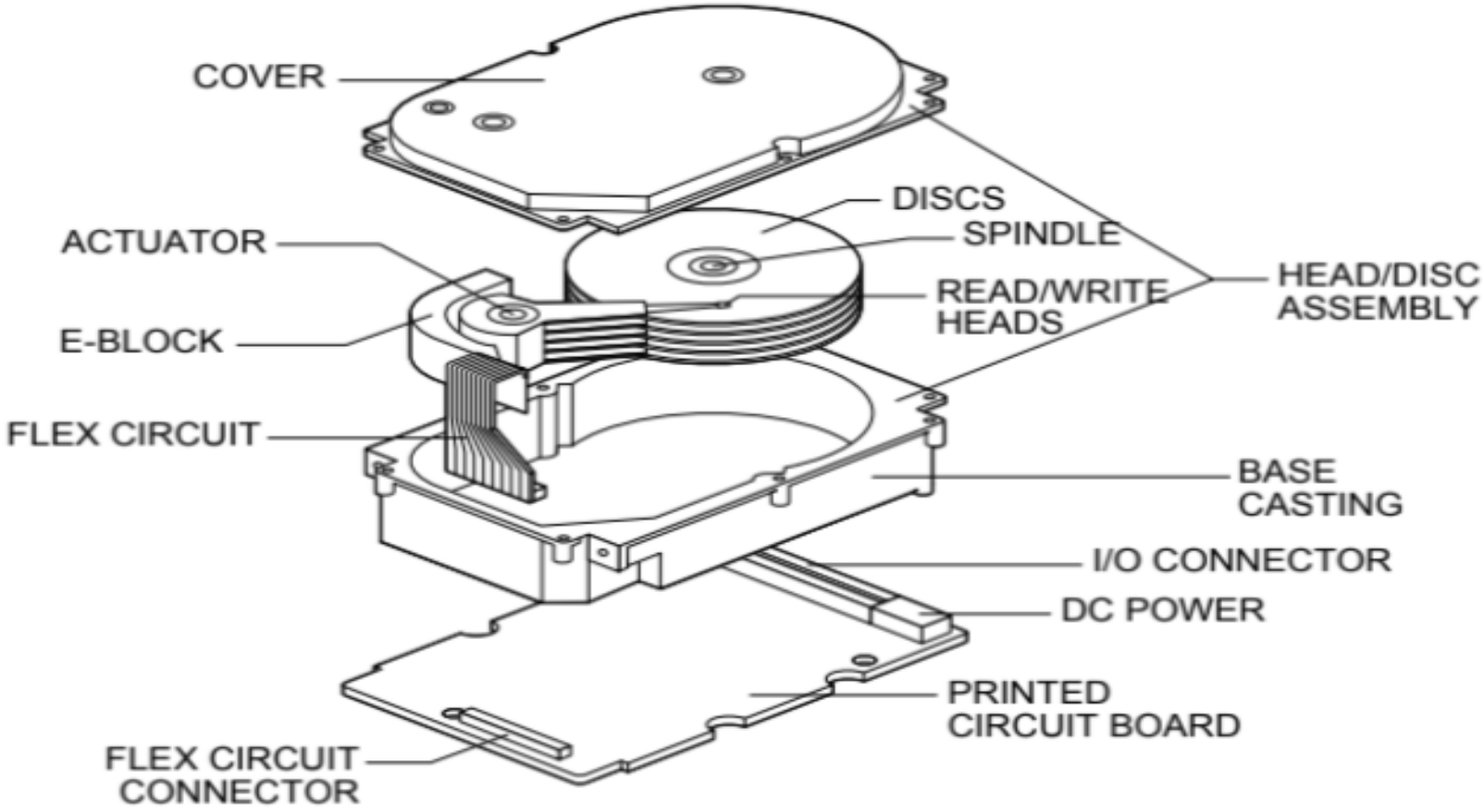

Figure 2: Diagram of the major components of a disc drive.

Mechanics

Actuator

- Larger magnets $\rightarrow$ Control $\uparrow$ Seek performance $\uparrow$
- Latch reduces seek performance near it
  - Magnetic interference
  - Bi-stable latch $\rightarrow$ No performance loss

HDA (Head/Disc assembly)

- 1,000,000+ hour MTBF acheived by
  - Particle filters
  - Dessicants and Active Carbon
  - Shrouding

Spindle

- Moving faster is a tremendous engineering challenge
  - Increased windage (airflow between disk and arm)
  - Mis-read/mis-write

Electronics

Control processor

- Handles read/write
- Servo bursts
  - Fields of positional information $\rightarrow$ Identify head's current position
  - Interspersed among data blocks

Servo processor

- Servo operations - Rotation, Speed, Direction adjustment
- More TPI $\rightarrow$ More servo processing
- Runout - Head is unable to follow the track
  - Repeatable runout — same on each rotation — caused by platter waviness, motor variation
  - Non repeatable — external influences — Harder to solve

Interface

- Significantly more Silicon in ES products
- ES have 2 processors
  - Control processor - Read/Write and interfacing
  - Servo processor - Only performs servo calculations
- PS have only one processor
- SCSI command set is also more comprehensive

Magnetics

- Writes - Data rate and latency improved by higher RPM, sensitive to linear velocity
- Reads - Can be adverally affected by high RPM because of noiser magnetic environment (Recording stress), insensitive to linear velocity
- Anti-ferromagnetic coupled media reinforces magnetic field

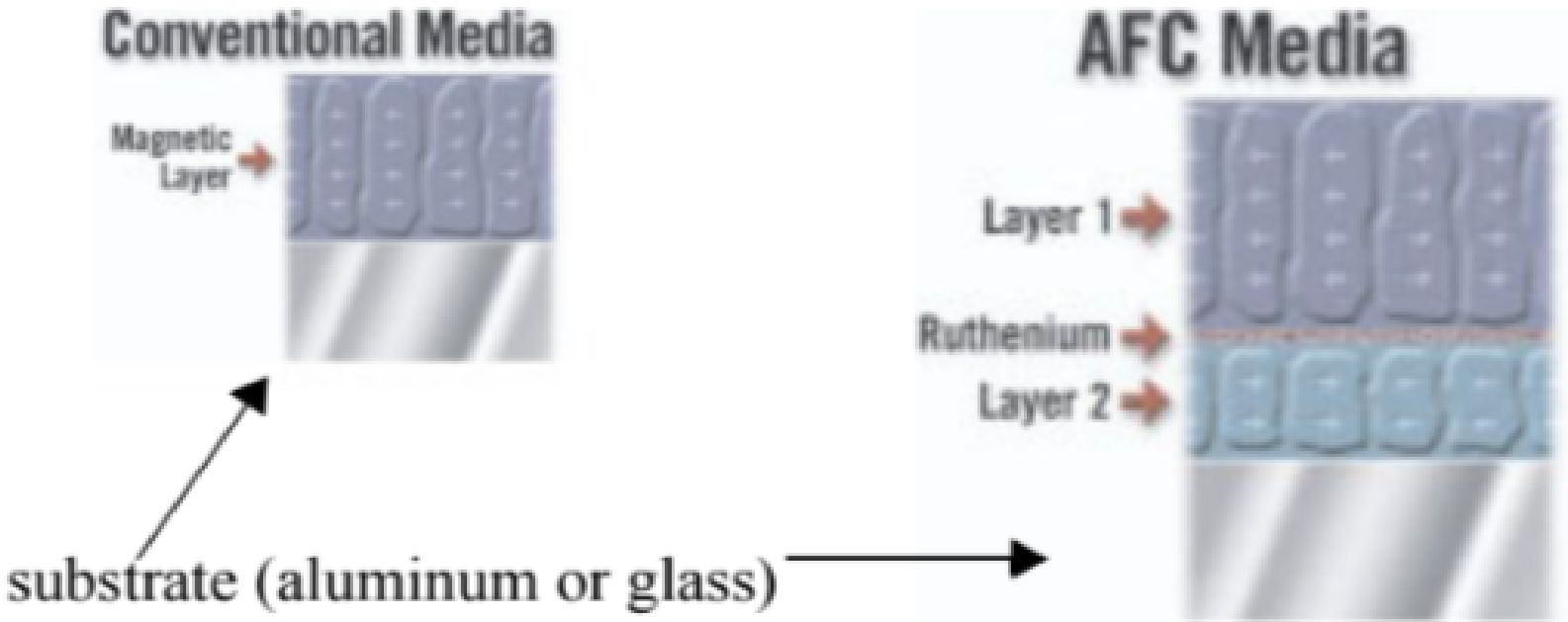

Figure 3: Diagram of media layers. The base substrate consists of either aluminum or glass, topped with a layer of magnetic material. In anti-ferromagnetically coupled (AFC) media, an additional layer of magnetic material and a layer of ruthenium are added, with the two layers reinforcing each other for better magnetic stability at higher density.

Perfomance Differences

Capacity

- $\text{Power} \propto (\text{RPM})^3$
- ES use smaller platters — RPM ↑ Seek performance ↑
- But for the same capacity more platters needed → costly
- PS drives → larger platters, lower RPM → cheaper per GB
- Trend towards depopulated drives (1 surface per platter) → Performance ↑ Capacity ↓

		cap	speed	density	dia	int bw (Mb/s)		ext bw
		GB	rpm	Gb/in^2		calc	spec	MB/s
Atlas 10k 18WLS	ES	18	10000	3.4	3.3”	-	314	24.6
DeskStar 75	PS	30	7200	11.0	3.7”	551	444	35.6
Cheetah 36LP	ES	18	10000	7.3	3.3”	579	427	-
Cheetah X15	ES	18	15000	7.3	2.5”	690	508	39.5
Cheetah X15-36LP	ES	36	15000	17.5	2.5”	969	709	57.7

Table 1: Comparison of drives with increasing data rates. Capacities, speeds, and densities are from published spec sheets. Diameters are typical for those spindle speeds. Internal bandwidths are calculated from the speed, diameter, and TPI as shown in the spec sheets. External bandwidths are as measured by LinuxHardware.org [Augustus01].

Random I/O

ES drives have:

- Stronger seek scheduling making seeks ~3x faster compared to PS
- >2x random perfomance (on average)
- Lower duty cycle

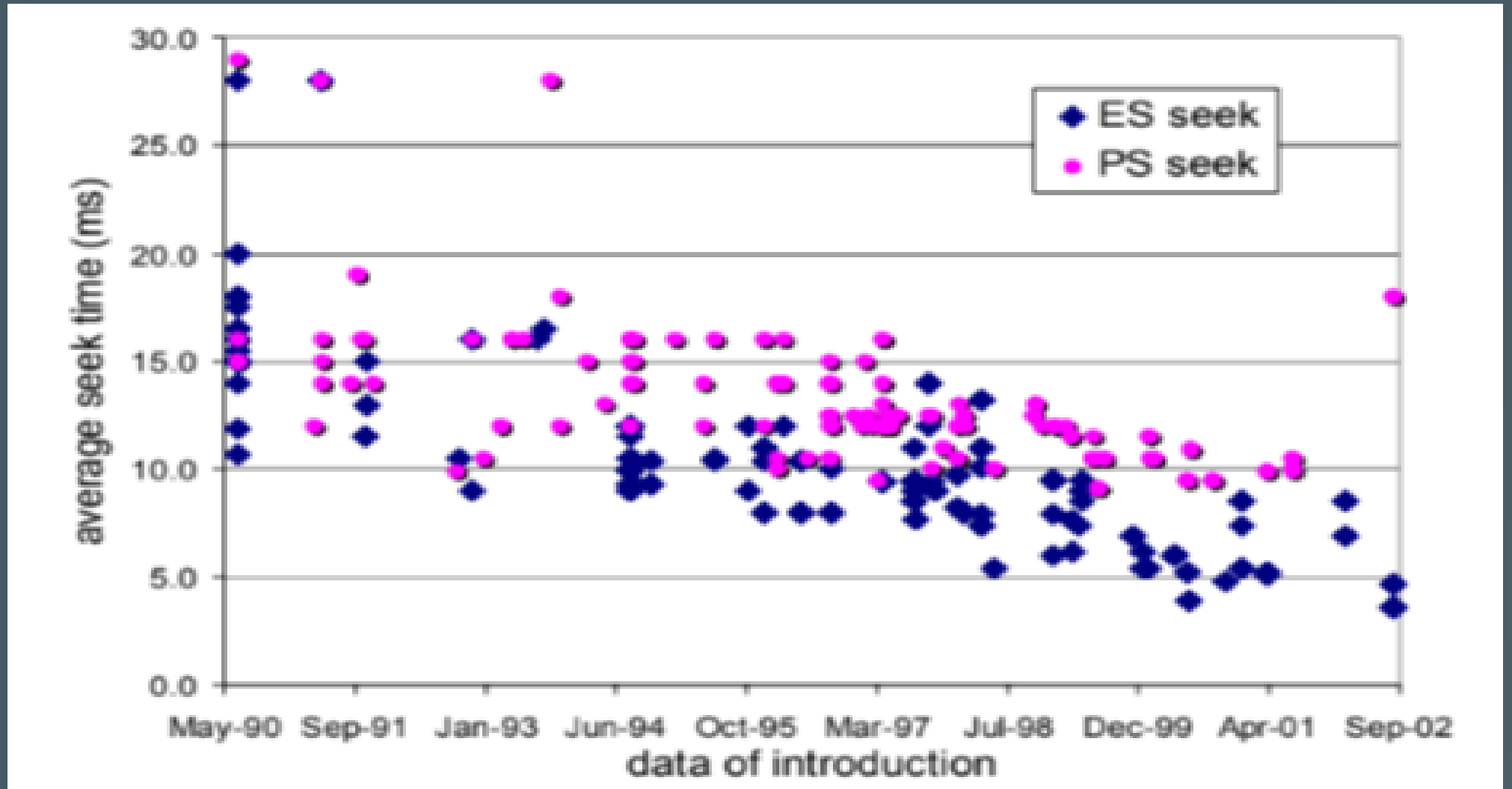

Figure 7: Comparison of seek times [Seagate02].

queue depth	read (8 KB)		write (8 KB)	
	PS	ES	PS	ES
1 requests	65 req/s	115 req/s	105 req/s	184 req/s
2 requests	66 req/s	116 req/s	105 req/s	184 req/s
4 requests	71 req/s	146 req/s	105 req/s	187 req/s
8 requests	79 req/s	174 req/s	105 req/s	190 req/s
16 requests	89 req/s	202 req/s	108 req/s	200 req/s
32 requests	101 req/s	235 req/s	108 req/s	213 req/s

Table 2: Comparison of random request rates at increasing queue depth on the same request stream in PS and ES drives. Both drives are run with write caches enabled. If the write cache on the ES drive were disabled, the improvement with larger queue depth would be even larger, as observed in a previous study [White01].

Rotational vibation

- PS drives way more susceptible to rotational vibration
- ES drives designed to work in cabinet with other drives
- Even cabinet design can affect rotational vibrations drastically

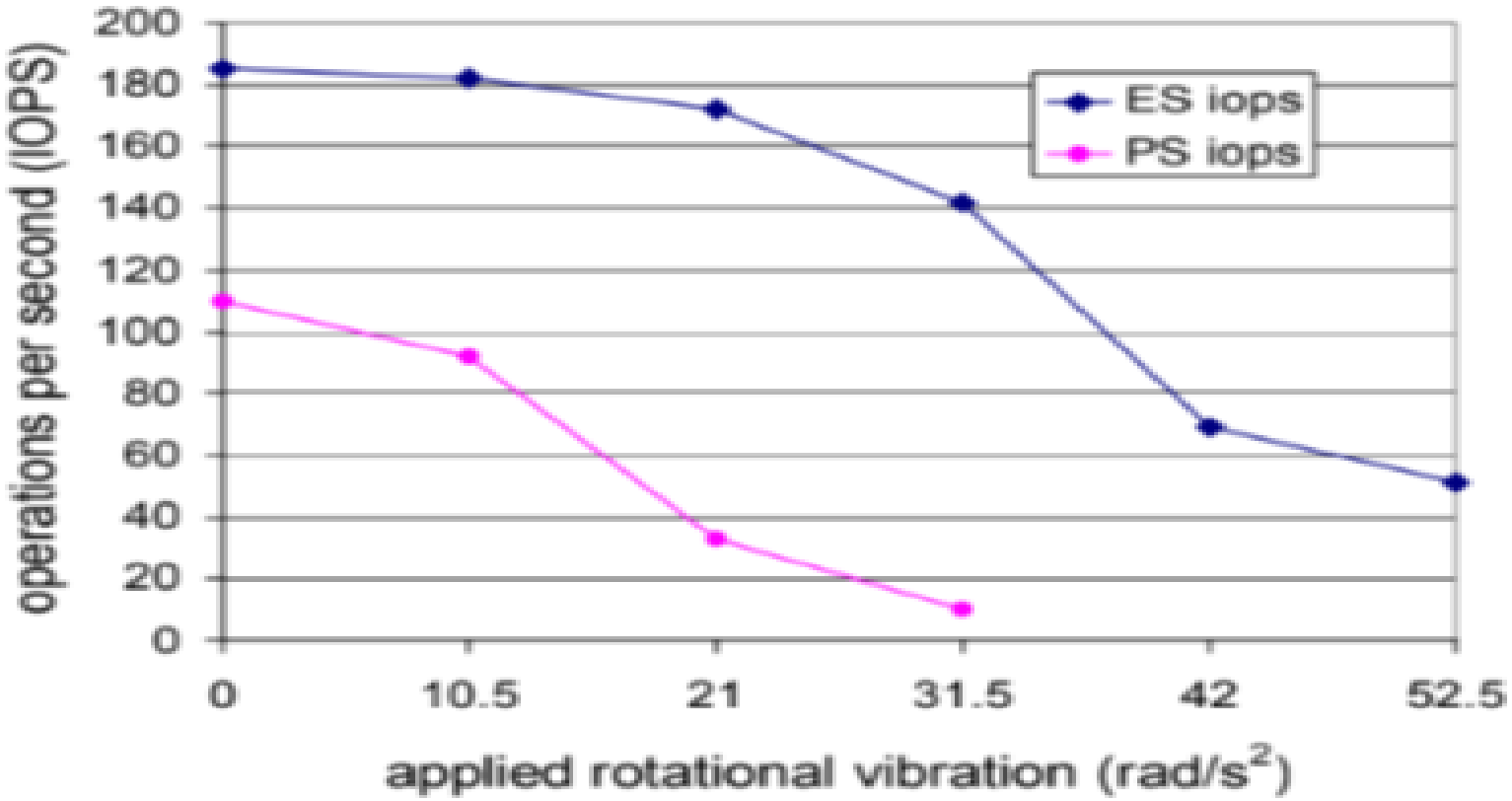

Figure 8: Externally applied rotational vibration can have a major, negative impact on performance. Individual drive cabinets vary widely in the amount of rotational vibration they transfer, and have been measured up to 45 rad/s² [Hall00]. Data for Seagate Cheetah 18LP and Barracuda III.

Reliability

- PS - 8 hrs/day 300 days/year, ES - 24 hrs/day, 365 days/year
- AFR highly depends in design choices

- POH $\propto$ AFR

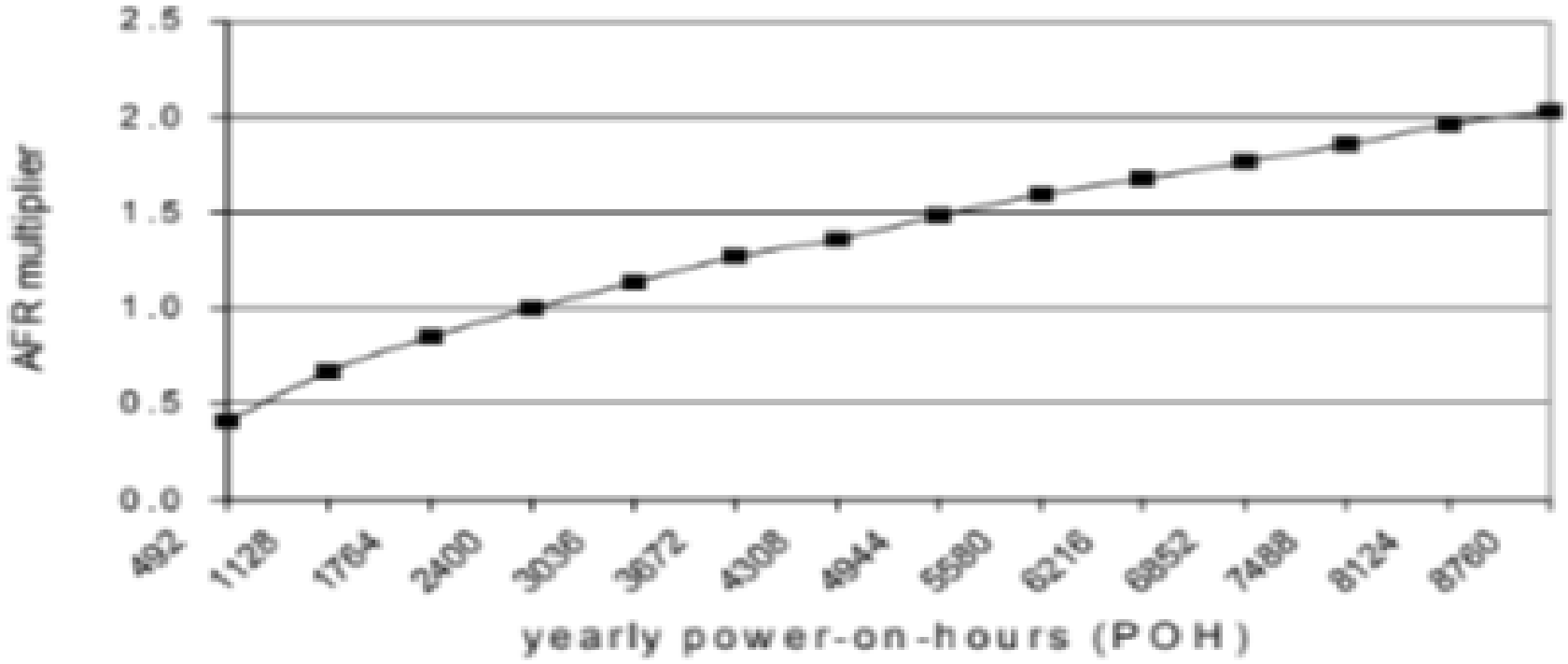

Figure 9: Reliability reduction with increased power on hours, ranging from a few hours per day to 24 x 7 operation [Cole00].

- Duty cycle $\propto$ AFR (stronger correlation with more platters)

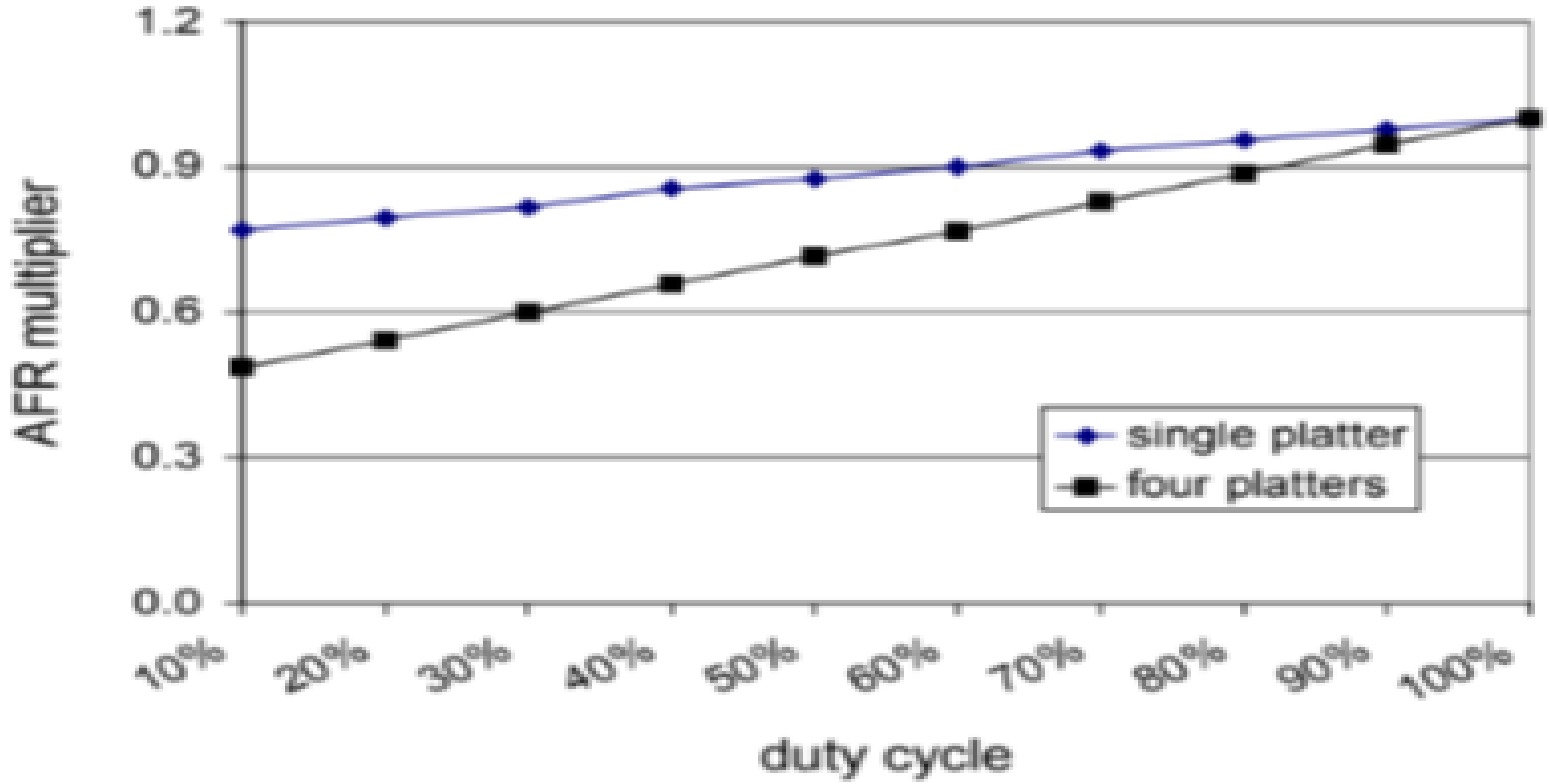

Figure 10: Reliability is decreased with higher duty cycle, and the effect is greater for drives with larger numbers of platters [Cole00].

- Temperature $\propto$ AFR

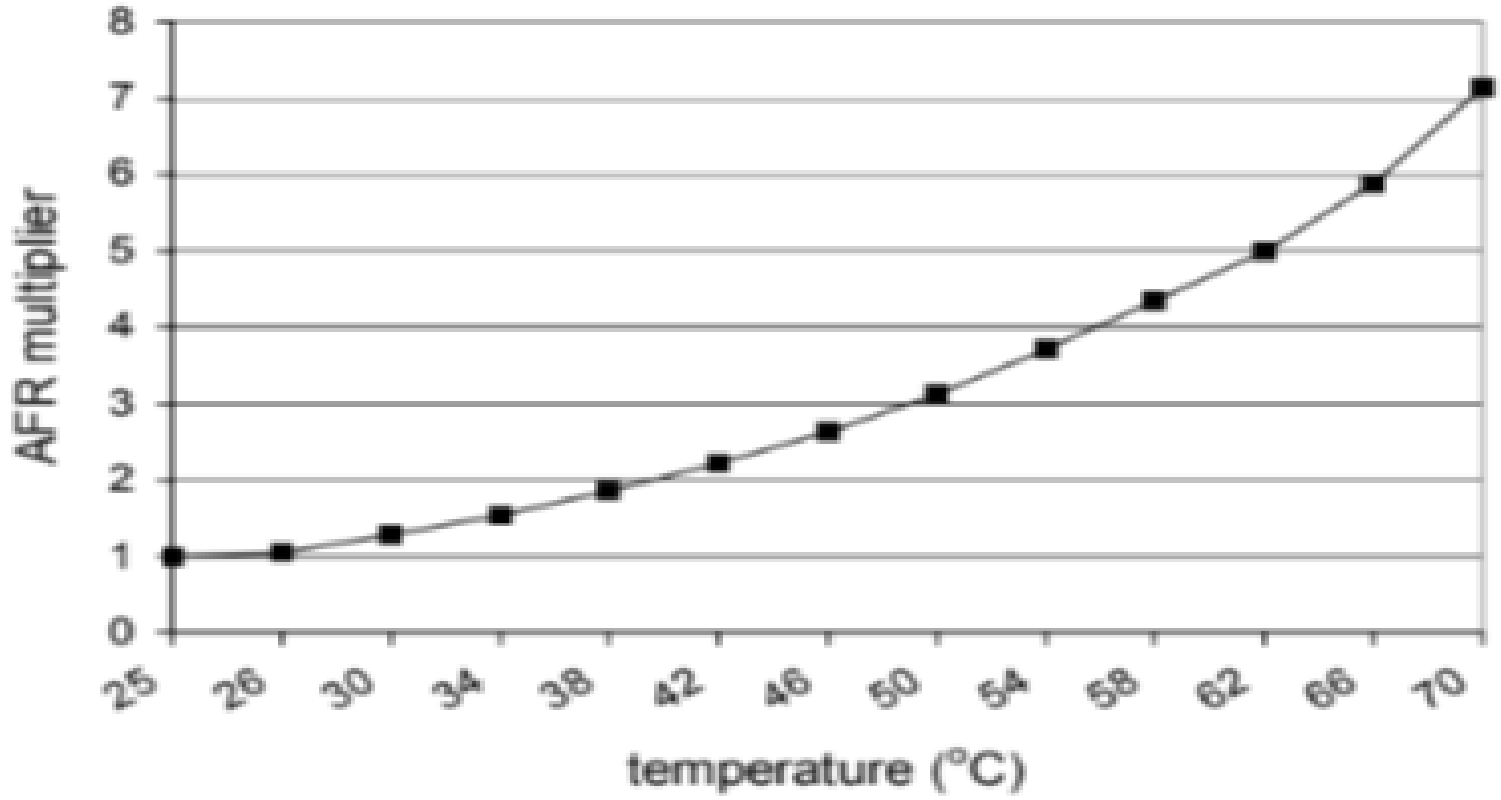

Figure 11: Reliability decrease due to ambient temperature variation [Cole00].

Related work

- Many studies have been conducted comparing SCSI vs IDE
- results depend a lot on design choices
- General observation - with similar conditions SCSI perform better than IDE

	iface	cap	price	speed	seek	density	kbpi	ktpi	internal bw				dia^	ext bw	dsks	cap
									3.7"	3.3"	3.0"	spec				raw
UltraStar 36LZX	SCSI	36 GB	$550	10000 rpm	4.9 ms	7.0 Gb/in^2	352	20.0	*645*	*610*	552	452 Mb/s	3.0"	36 MB/s	6	594 Gb
DeskStar 75	ATA	30 GB	$159	7200 rpm	8.5 ms	11.0 Gb/in^2	391	28.4	551	*487*	*442*	444 Mb/s	3.7"	37 MB/s	2	483 Gb

Table 4: Comparison of PS and ES drives from IBM [White01]. The Deskstar drive has a slight advantage in sequential bandwidth, even though the UltraStar has a higher rpm. The authors of the previous study attribute this to overhead in the SCSI interface. In fact, a closer look at the physical discs shows the most likely explanation a smaller platter size in the UltraStar (3.0" instead of the normal 3.7"). This reduces seek time at the expense of lower sequential bandwidth on the outer tracks. Since the UltraStar has a much lower areal density, it must also make up the capacity difference by using additional platters (6 vs. 2). ^estimated based on the internal transfer rate and raw capacity differences

	iface	cap	price	speed	seek	density	kbpi	ktpi	int bw		dia	ext bw	disks	cap
									calc	spec				raw
UltraStar 36Z15	SCSI	36 GB	$381*	15000 rpm	4.1 ms	10.7 Gb/in^2	397	27.0	798	647 Mb/s	2.6"	53 MB/s$^{\%}$	6	661 Gb
DeskStar 120	ATA	60 GB	$99	7200 rpm	8.5 ms	29.7 Gb/in^2	547	54.0	771	592 Mb/s	3.7"	48 MB/s$^{\%}$	2$^{\#}$	979 Gb

Table 5: Comparison of a newer generation of drives from IBM. In this case, the new UltraStar increases sequential performance over the new DeskStar due to the higher spindle speed, even though the areal density is lower. *from Harddrive.com in August 2002 %according to the published specification, not a measured number #the 60 GB version of the DeskStar 120 has 2 disks, but only 3 heads, one surface remains unused

	cap	seek	speed	density	dia	int bw (Mb/s)		ext bw
	GB	ms	rpm	Gb/in^2		calc	spec	MB/s
Fireball lct 08	26	9.5	5400	6.1	3.7"	343	257	19
Atlas 10K (SCSI)	18	4.5	10000	3.4	3.3"	444	314	24

Table 6: Comparison ATA vs. SCSI under Windows 2000 [Chung00].

Conclusion

- In order to compare to drive models a detailed comparison of drive specifications is needed
- All the factors explained before contribute to perfomance and we cannot compare solely based on interface (ATA vs SCSI)

Questions?