

<https://youtu.be/B1MGsgsr9GE>

Western Digital Vídeo

Memórias Externas RAID Architecture

Frase do dia:

**“O que sabemos é uma gota; o
que ignoramos é um oceano.”**

Sir Isaac Newton



IDENTIKIT E DADOS PESSOAIS

Nome Isaac

Sobrenome Newton

Título Sir

Nascido 4 Janeiro 1643 em Woolsthorpe-by-ColsterworthLincolnshire

Falecido 31 Março 1727 em Kensington, Londres

Gênero masculino

Nacionalidade Inglesa

Profissão matemático, físico

Signo do zodiaco Capricórnio

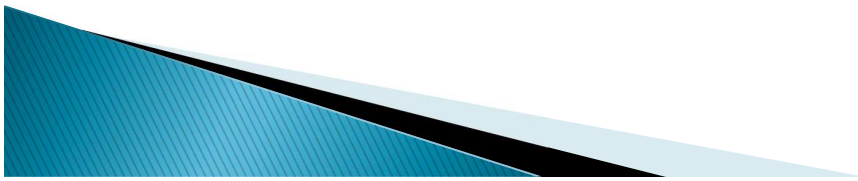


Avisos: CC-03AN – Datas Importantes

- **Avaliação N1: 20/10/2022 – 21h10**
- **Avaliação N2:**
 - **Apresentação dos Grupos: 17/11/2022**
 - **Avaliação Integrada (AI) parte da N2: 21 a 23/11/2022**
 - **Avaliação Processual (AP) – 100% - Fechamento 30/11/2022**
 - **40% - Seminário sobre TI – Formulário Grupos e Temas 02/10/2022**
 - **60% - Atividades**
 - **In class**
 - **Formulários**
- **Prova N3: 15/12/2022 – 21h10**

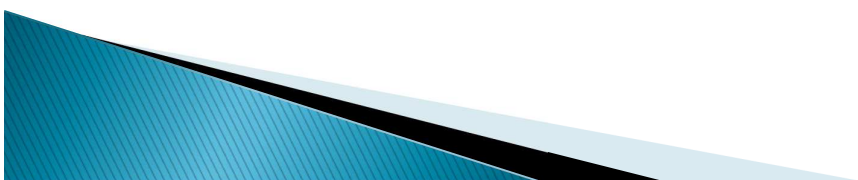
Introduction

- ▶ RAID stands for Redundant Array of Independent Disks
- ▶ A system of arranging multiple disks for redundancy (or performance)
- ▶ Term first coined in 1987 at Berkley
- ▶ Idea has been around since the mid 70's
- ▶ RAID is now an umbrella term for various disk arrangements
 - Not necessarily redundant

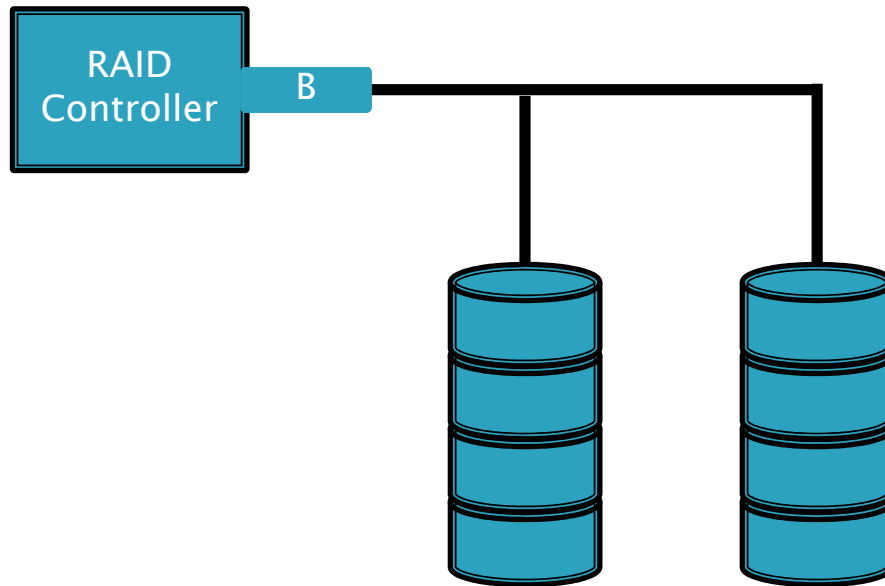


RAID 0

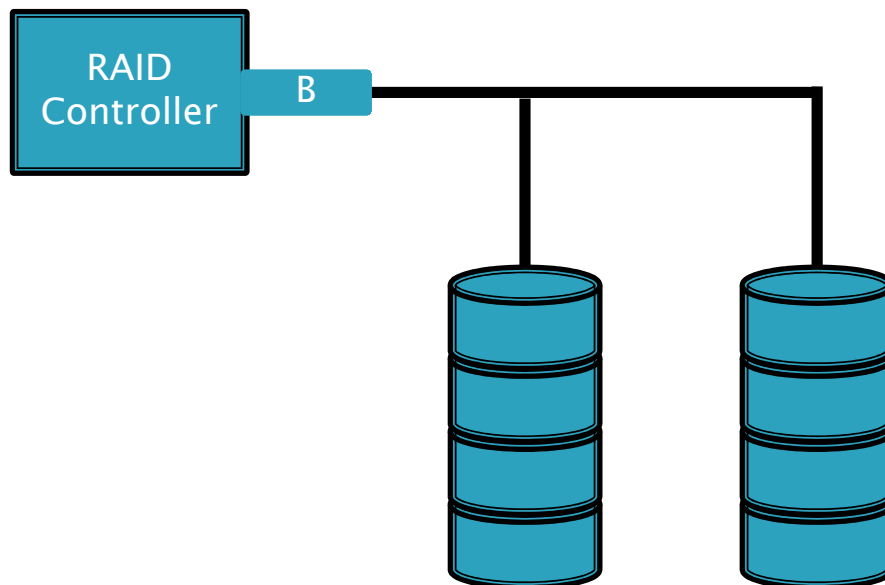
- ▶ Also known as “Striping”
- ▶ Data is striped across the disks in the array
- ▶ Each subsequent block is written to a different disk



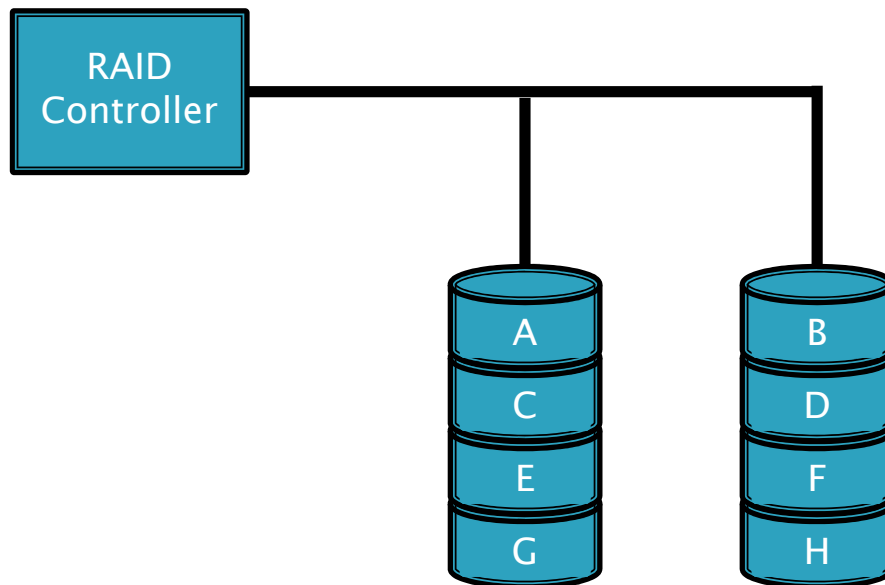
RAID 0 Writes



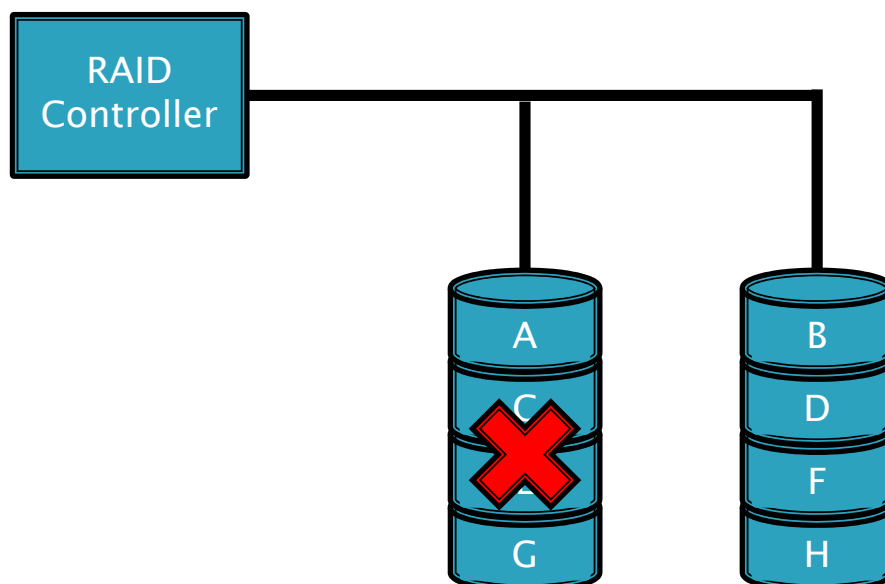
RAID 0 Writes



RAID 0 Reads

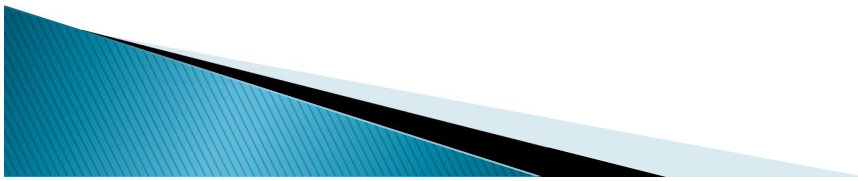


RAID 0 Recovery



RAID 0 Pros

- ▶ Best use of space
 - Every byte of the disks can be accessed in the array
- ▶ Very fast reads and writes
 - The more disks you add to the array, the faster it goes
- ▶ Simple design and operation
 - No parity calculation



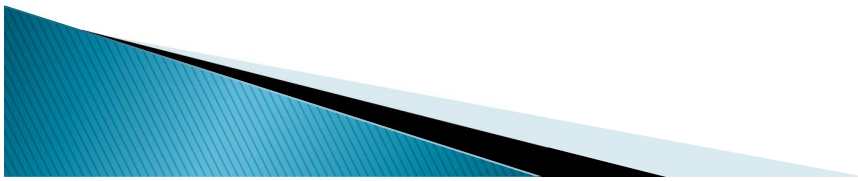
RAID 0 Cons

- ▶ No redundancy
- ▶ Not for use in mission critical systems
- ▶ One disk failure means all your data is unrecoverable

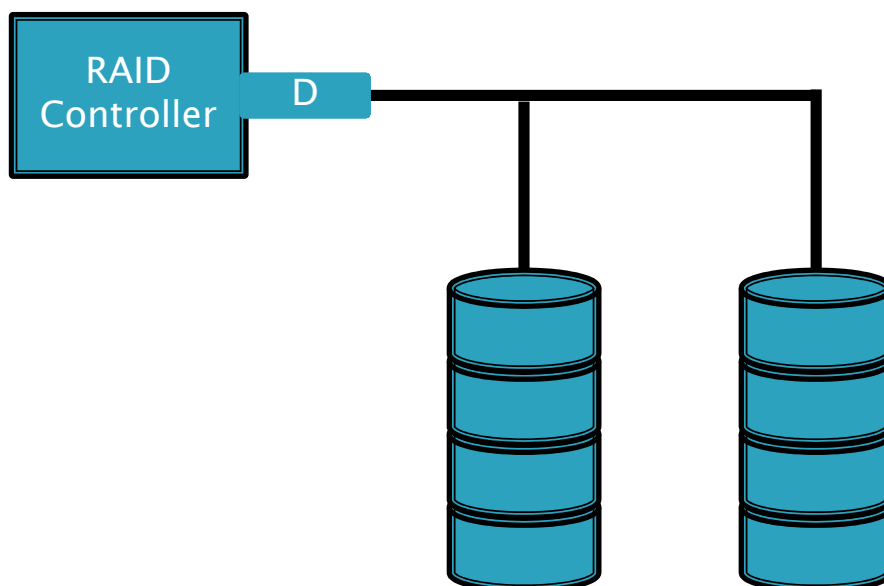


RAID 1

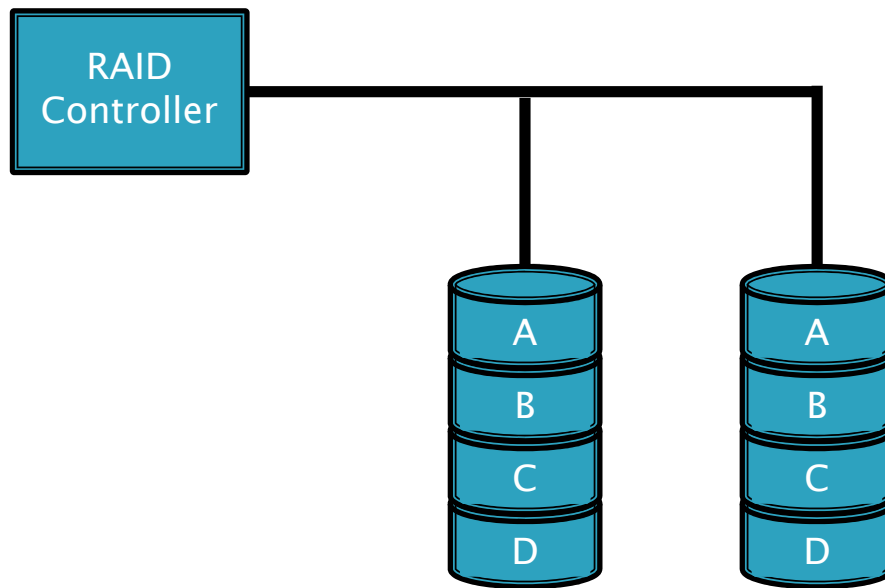
- ▶ Known as “Mirroring”
- ▶ Data is written to two disks concurrently
- ▶ The first type of RAID developed



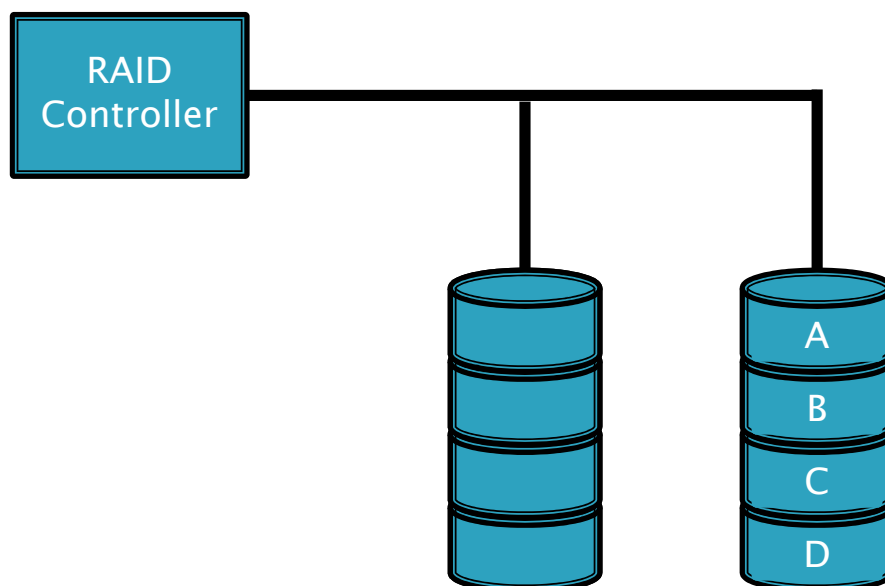
RAID 1 Writing



RAID 1 Reading

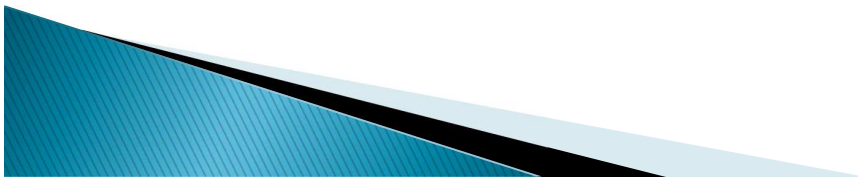


RAID 1 Recovery



RAID 1 Pros

- ▶ Good redundancy
 - Two copies of every block
- ▶ Fast reads
 - Can read 2 blocks at once (more if more disks)
- ▶ Writes are acceptable
- ▶ No intense calculation on rebuild, just copy



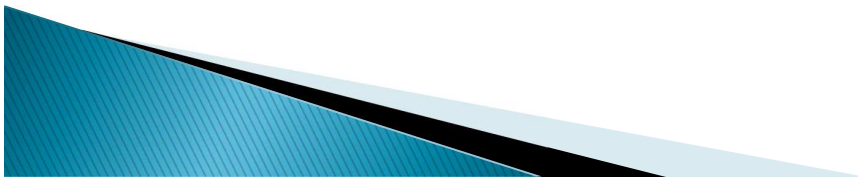
RAID 1 Cons

- ▶ SPACE!!
- ▶ Using 2 disks gives you 1/2 the space, using 3 gives 1/3 etc...
- ▶ Writes are not as fast as other RAID types
- ▶ Very expensive

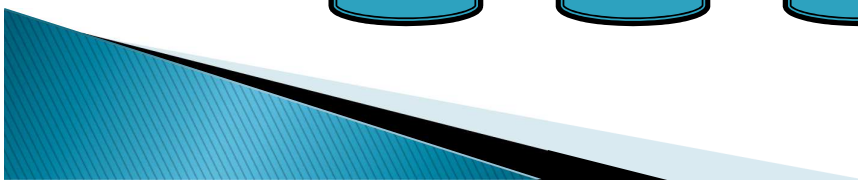
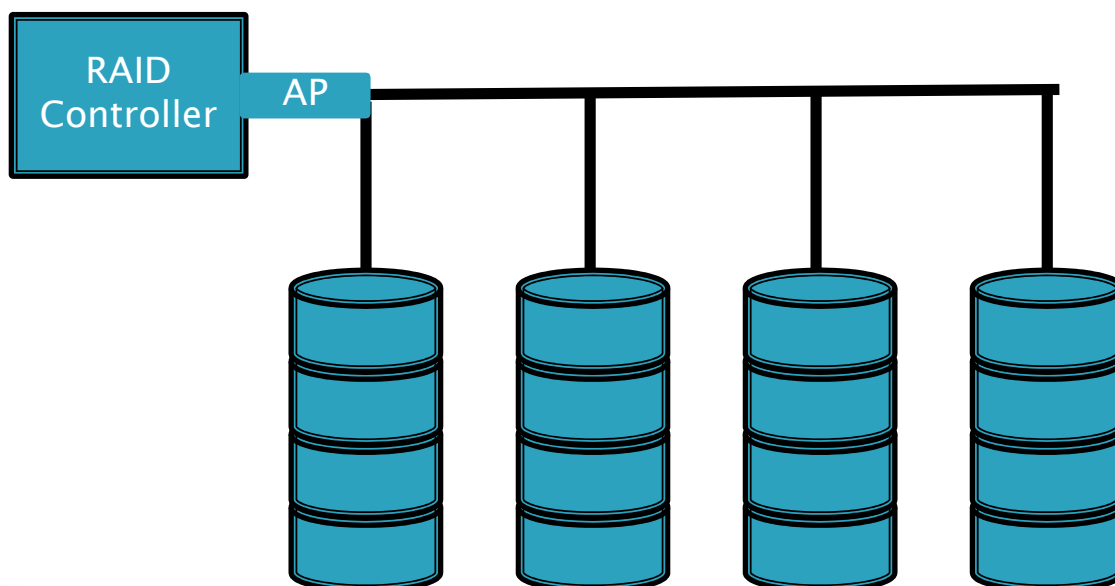


RAID 4

- ▶ Striping with a dedicated parity disk
- ▶ Blocks are written to each subsequent disk
- ▶ Each block of the parity disk is the XOR value of the corresponding blocks on the data disks
- ▶ Not used often in the real world



RAID 4 Writing



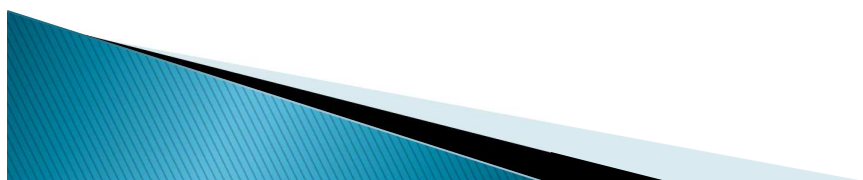
RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	



RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	1



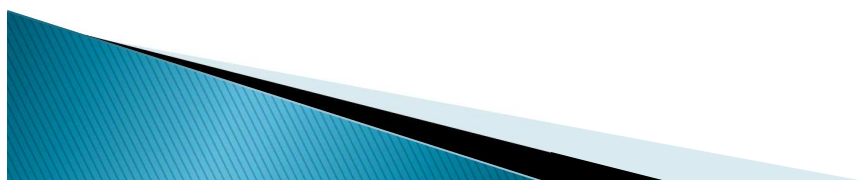
RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	10



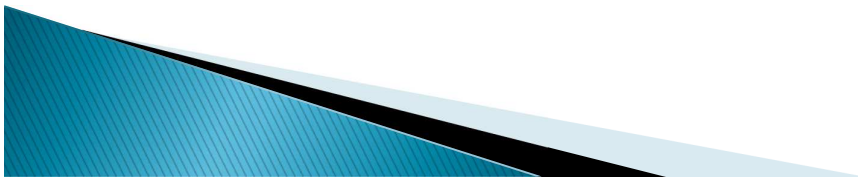
RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	100



RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	1001



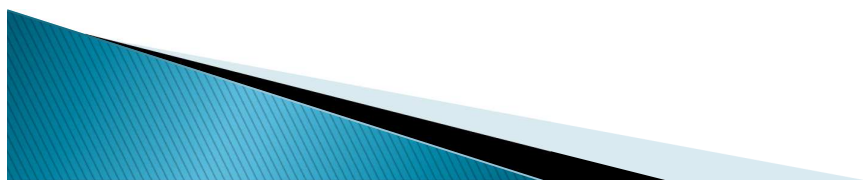
RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	10010



RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	100101



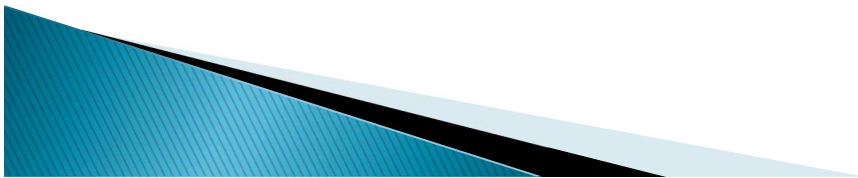
RAID 4 Writing

Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	1001011

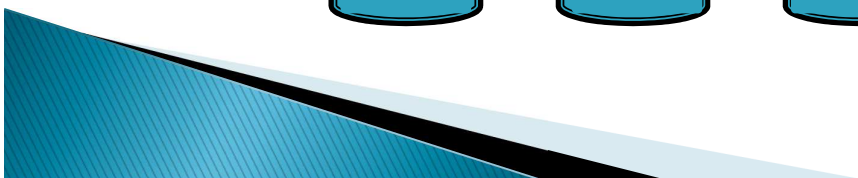
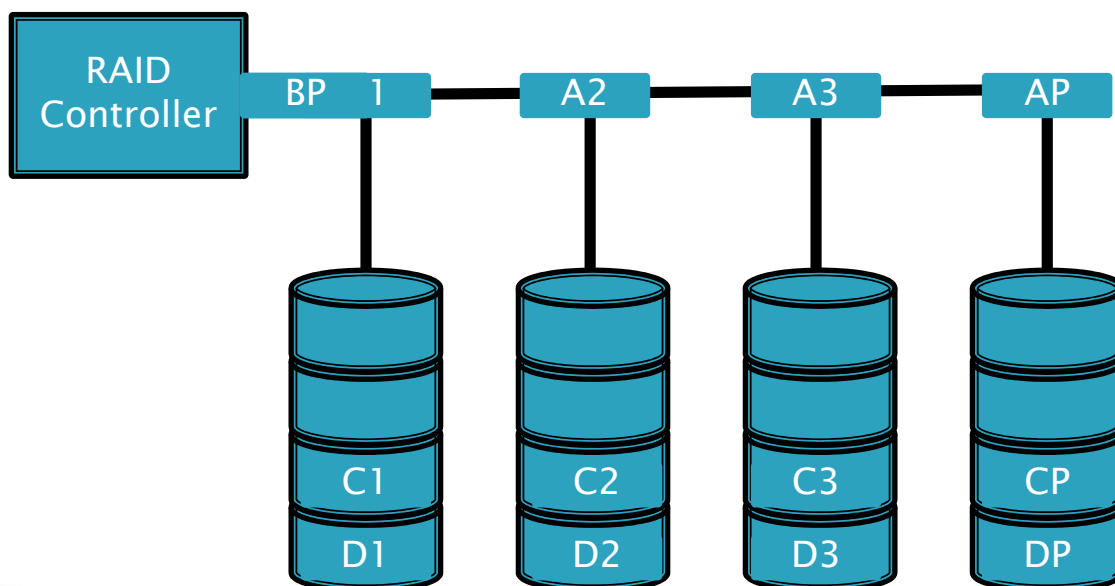


RAID 4 Writing

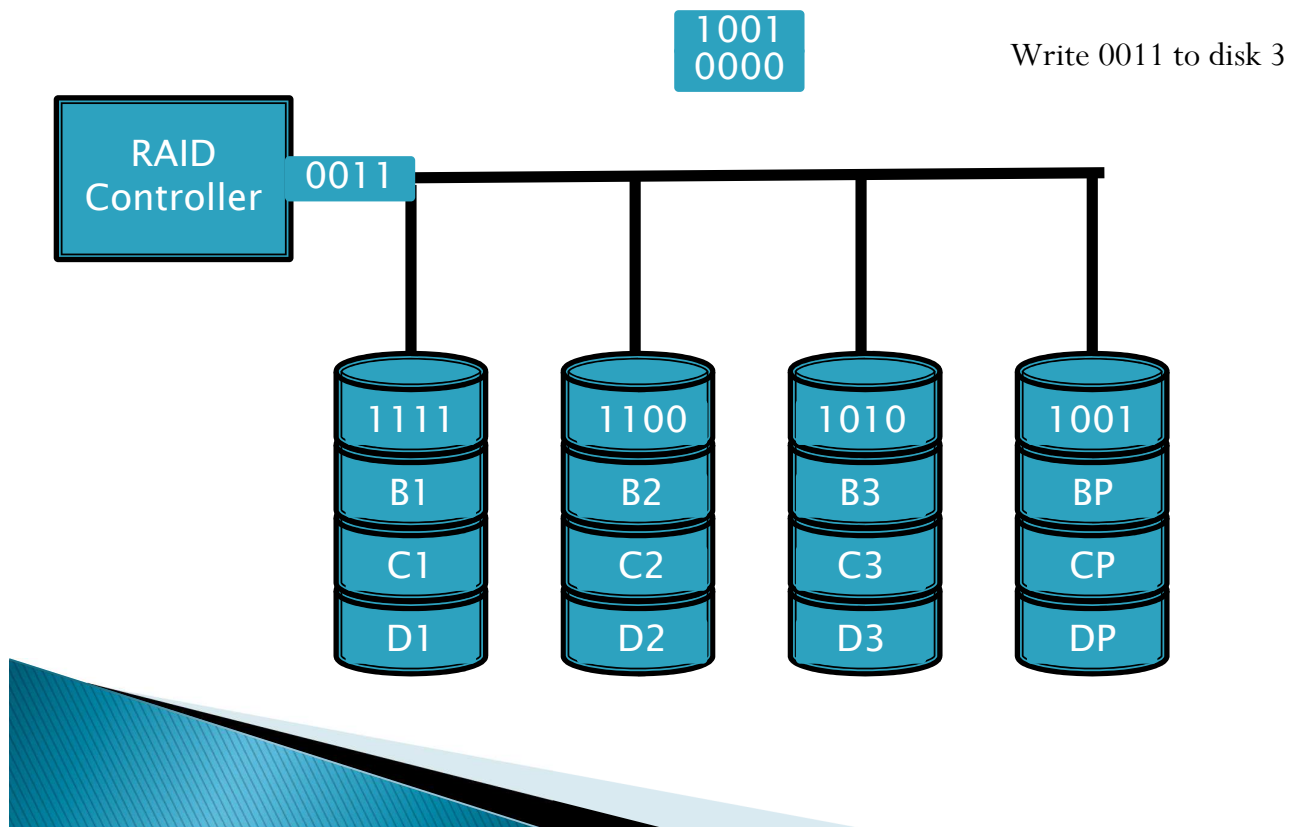
Block	Data
A1	11110000
A2	11001100
A3	10101010
AP	10010110



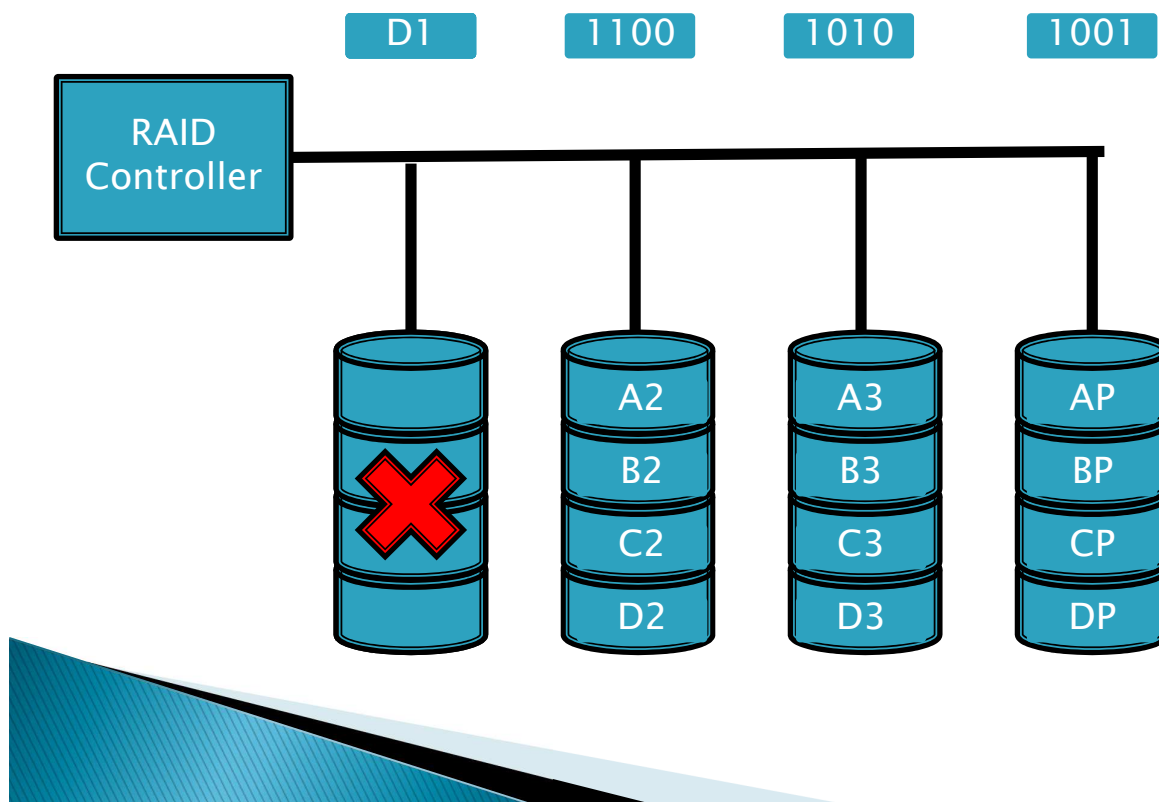
RAID 4 Writing



RAID 4 Modifying

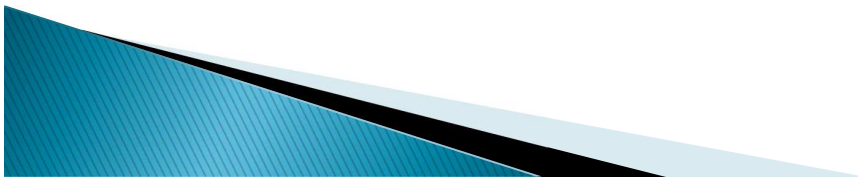


RAID 4 Recovery



RAID 4 Pros

- ▶ High read rate
- ▶ Low ratio of error correction space
 - Any number of data disks only require 1 parity disk.
4 disks gives 3/4 usable space 5 gives 4/5
- ▶ Can recover from single disk failures



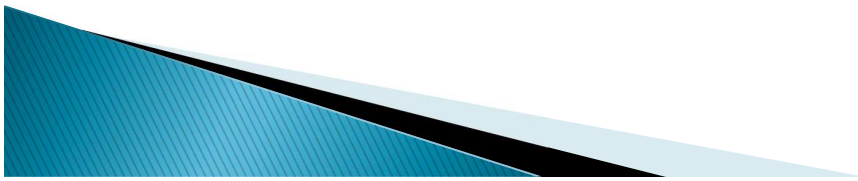
RAID 4 Cons

- ▶ Very slow writes
 - Every write requires 2 reads and 2 writes
 - Every write requires accessing the single parity disk
- ▶ Recovery is processor intensive
- ▶ Parity bit cannot detect multi-bit error

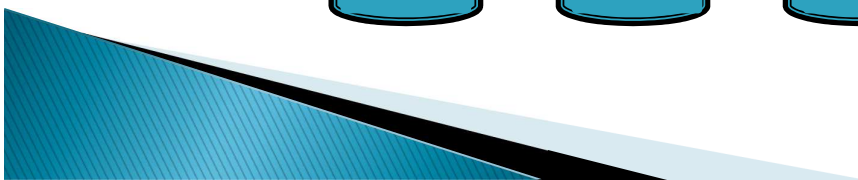
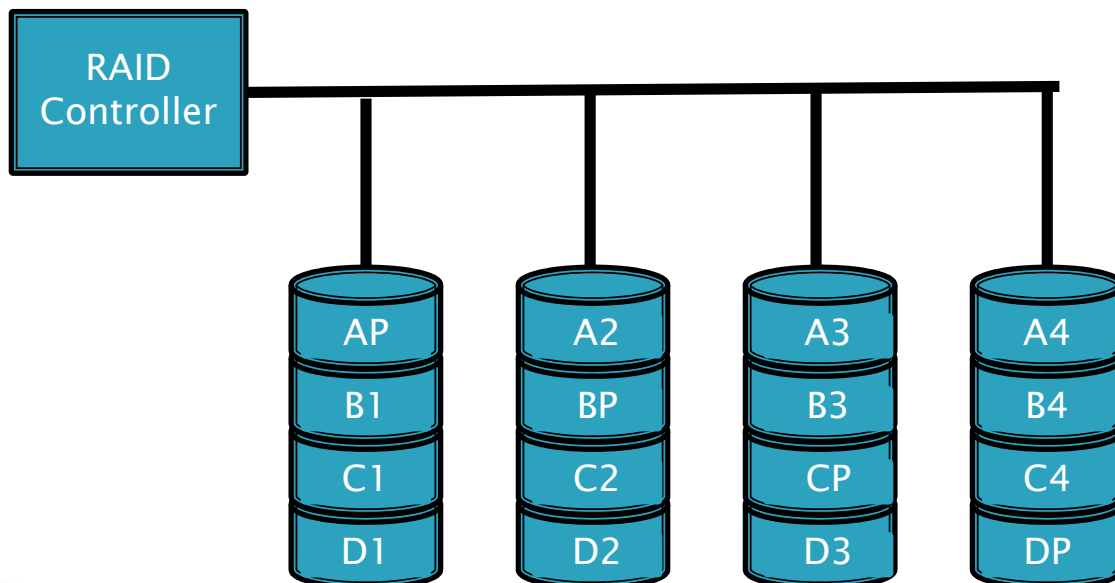


RAID 5

- ▶ Striped disks with interleaved parity
- ▶ Much like RAID 4 except that parity blocks are spread over every disk

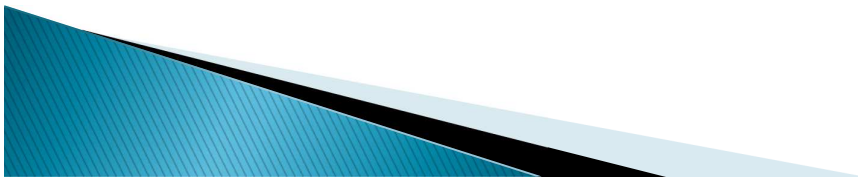


RAID 5



RAID 5 Pros

- ▶ Read rates the same as RAID 4
- ▶ Because parity bits are distributed, every write does not need to access a single disk
 - Writes are marginally better than RAID 4
- ▶ Like RAID 4, you need relatively little parity which allows larger arrays



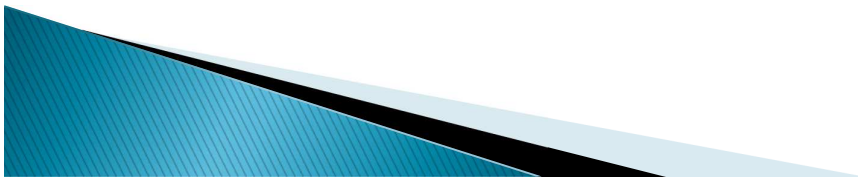
RAID 5 Cons

- ▶ Re-writing a block still requires 2 reads and 2 writes
 - Interleaving mitigates the penalty
- ▶ Rebuilding the array takes a long time
- ▶ Can only tolerate one disk failure



RAID 2

- ▶ Striped set with dual distributed parity
- ▶ Defined as any form of RAID that can recover from two concurrent disk failures
- ▶ Different implementations
 - Double parity, P+Q, Reed–Solomon Codes
- ▶ Essentially RAID 5 with an extra parity disk



RAID 2 Error Correction Using Hamming Codes (Double parity)

	Data				Redundant		
Disk	1	2	3	4	5	6	7
	1	1	1	0	1	0	0
	1	1	0	1	0	1	0
	1	0	1	1	0	0	1



	Data				Redundant		
Disk	1	2	3	4	5	6	7
	1	1	1	0	1	0	0
	1	1	0	1	0	1	0
	1	0	1	1	0	0	1

Hamming Code

Data

Disk	Contents
1	11110000
2	????????
3	00111000
4	01000001
5	????????
6	10111110
7	10001001

	Data				Redundant		
Disk	1	2	3	4	5	6	7
	1	1	1	0	1	0	0
	1	1	0	1	0	1	0
	1	0	1	1	0	0	1

Hamming Code

Data

Disk	Contents
1	11110000
2	????????
3	00111000
4	01000001
5	????????
6	10111110
7	10001001

No Good! Disk 2 has failed.

	Data				Redundant		
Dis k	1	2	3	4	5	6	7
	1	1	1	0	1	0	0
	1	1	0	1	0	1	0
	1	0	1	1	0	0	1

Hamming Code

Data

Dis k	Contents
1	11110000
2	????????
3	00111000
4	01000001
5	????????
6	10111110
7	10001001

Great. We can recover disk 2 by using disks 1, 4, and 6. XOR them all and we get...

	Data				Redundant		
Dis k	1	2	3	4	5	6	7
	1	1	1	0	1	0	0
	1	1	0	1	0	1	0
	1	0	1	1	0	0	1

Hamming Code

Data

Dis k	Contents
1	11110000
2	00001111
3	00111000
4	01000001
5	????????
6	10111110
7	10001001

	Data				Redundant		
Disk	1	2	3	4	5	6	7
	1	1	1	0	1	0	0
	1	1	0	1	0	1	0
	1	0	1	1	0	0	1

Hamming Code

Data

Disk	Contents
1	11110000
2	00001111
3	00111000
4	01000001
5	???????
6	10111110
7	10001001

Now we can see disk 5 is the parity bit for disks 1,2,3. XOR them all and we have recovered from two disk failures.

	Data				Redundant		
Disk	1	2	3	4	5	6	7
	1	1	1	0	1	0	0
	1	1	0	1	0	1	0
	1	0	1	1	0	0	1

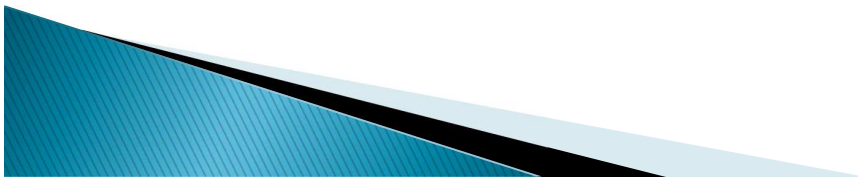
Hamming Code

Data

Disk	Contents
1	11110000
2	00001111
3	00111000
4	01000001
5	11000111
6	10111110
7	10001001

RAID 2 Continued

- ▶ In the example shown, we have not interleaved the parity information to make it easier to understand
- ▶ We can interleave the data in the same way we do in RAID 5 to avoid the bottleneck of writing all the parity to a small subset of disks



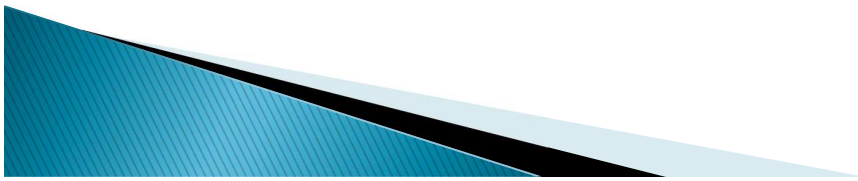
RAID 2 Pros

- ▶ Fast reads
- ▶ Very fault tolerant
- ▶ As rebuild times increase, having extra fault tolerance is becoming more important
- ▶ The parity method described requires $2^k - 1$ disks with k disks used for parity
- ▶ Other methods can require only 2 disks for parity



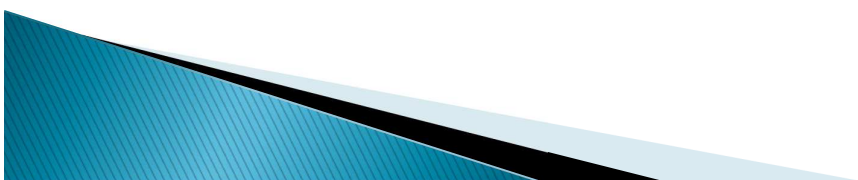
Raid 2 Cons

- ▶ About the same performance write speed as RAID 5. More reads and writes are required, but most can be done concurrently.
- ▶ Requires more parity space than RAID 5
 - Still less than RAID 1
- ▶ Very computationally expensive



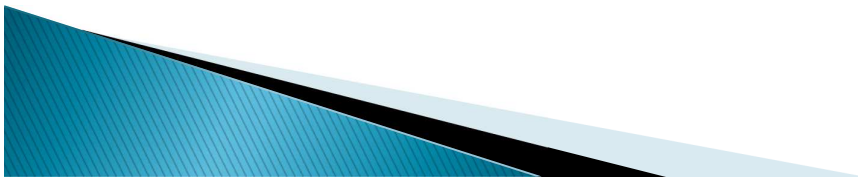
RAID 3

- ▶ Bit-interleaved parity
- ▶ Instead of using several disks to store Hamming code, as in RAID 2, RAID 3 has a single disk check with parity information.
- ▶ Performance is similar between RAID 2 and 3



Hybrids

- ▶ RAID 1+0
 - Sets of drives in RAID 1 act as the drives for RAID 0
 - Very fast reads
 - Faster writes than RAID 5
 - Redundant yet none of the overhead that comes with RAID 5 or 6
 - In certain cases can handle multiple failures
 - Very expensive

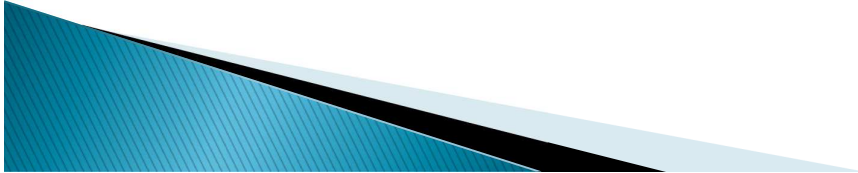


Hybrids Cont.

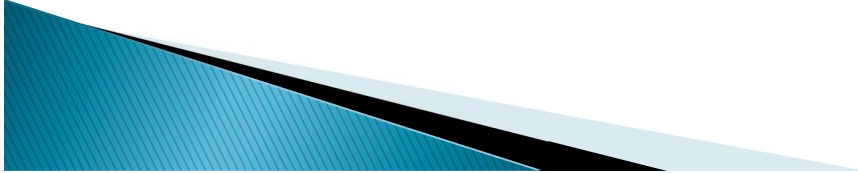
- ▶ Others
 - 5+0
 - 0+1
 - Hot Spares
 - Intel Matrix Raid



Software RAID (Fake RAID)

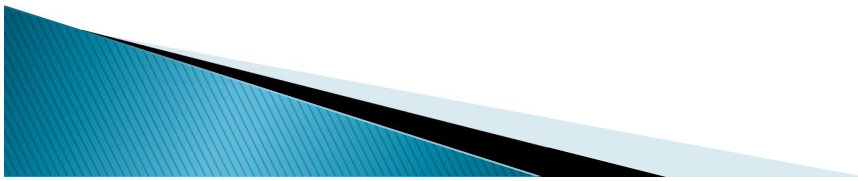
- ▶ Software controllers offload their error correction calculations to the CPU
 - ▶ Cheap
 - ▶ Included on nearly every modern motherboard
 - ▶ Difficult to boot from
- 

Hardware RAID

- ▶ No CPU overhead
 - ▶ Can include battery backed write cache
 - ▶ Can appear as a single disk to the BIOS
 - ▶ Often very expensive
 - (Some cost more than the hard drives used to build the array)
 - ▶ Proprietary (if your controller card fails, other manufacturers cards wont be able to read the array)
- 

Problems Inherent in all RAIDs

- ▶ Correlated Failures
 - Identical disks produced from the same assembly line and run for the exact same amount of time tend to fail together
- ▶ Write Atomicity
 - What happens when there is a system crash between a block being written and its associated parity block?



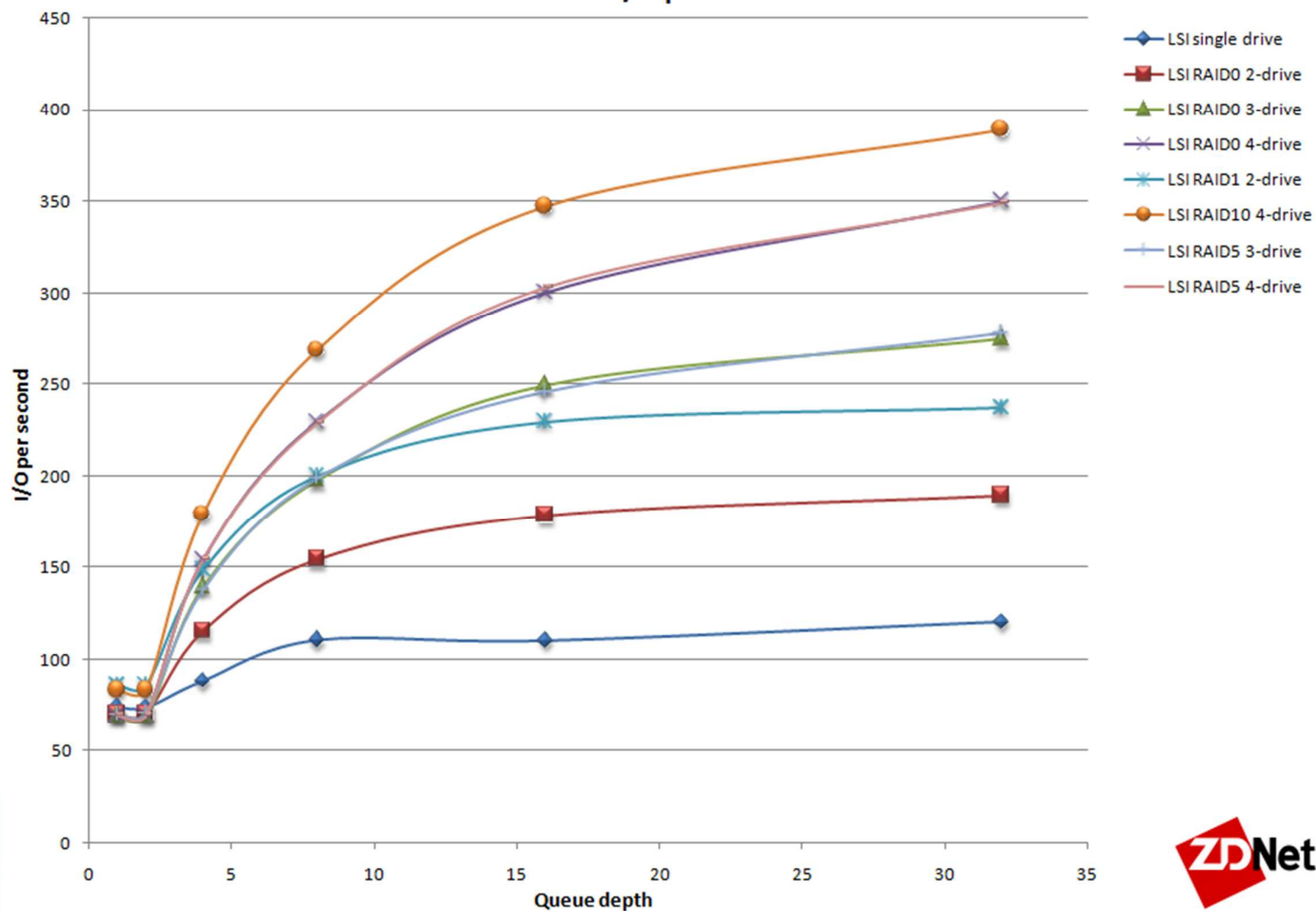
Problems Cont.

- ▶ RAID does not protect from bad data overwriting your good data
 - Viruses
 - User Error
- ▶ RAID solves the problem of uptime and availability, not data integrity.

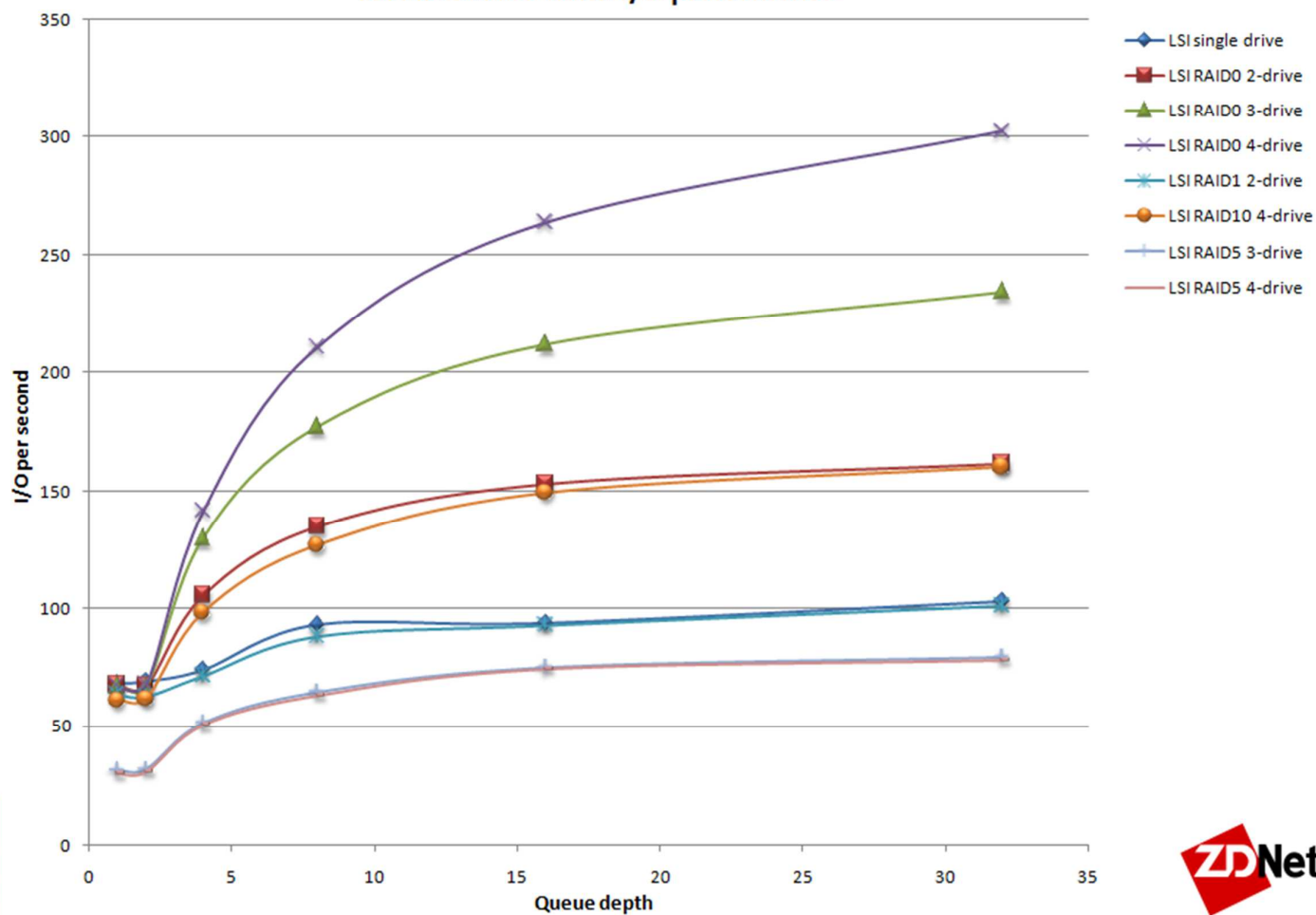




LSI File Server read I/O performance

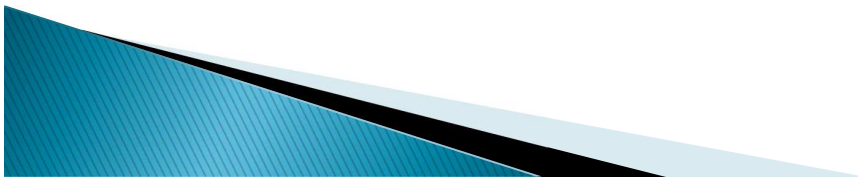


LSI File Server write I/O performance

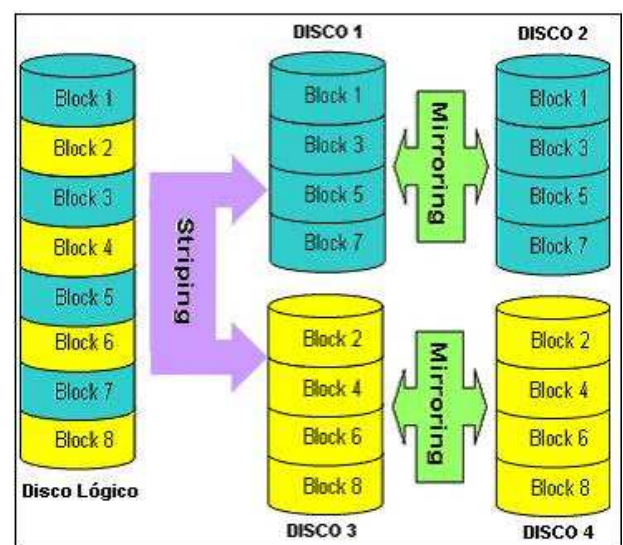
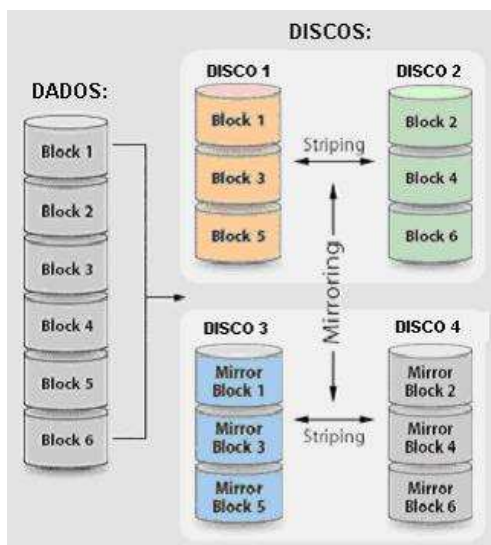


Applications

- ▶ RAID 0
 - Photoshop scratch disk
 - Video editing workstation
- ▶ RAID 5/6
 - File server
 - Web server with static content
- ▶ RAID 1+0
 - Database server



Hybrid 0+1 and 1+0 How is the better?



1P

Elkhorn Creek



SEAGATE



Servidor de Storage - Pentium® G / Xeon® E3-V3 Modelo Elkhorn Creek Storage, 8G, SSD120, 5x HD8TB

- » Processador Intel® Pentium® G-3260 ou Intel® Xeon® E3-V3 [+]
- » Placa Mãe Supermicro® X10SLL-HF [+]
- » 8 GB de Memória Kingston® DDR3-1600 ECC [+]
- » SSD: Drive Sólido de 120 GB, Kingston® SV300S37A/120G [+]
- » RAID 0/1/10/5: 05 (Cinco) Hard Disks de 8 TB, Seagate® SATA 6Gbps, Cache 128MB [+]
- » RAID suportado em Windows® Server 2003/2008/2012, Red Hat e SUSE Linux
- » Sem Unidades Óticas (CD, DVD) [+]
- » 02 Portas de Rede Gigabit: Intel® i210AT + i217LM
- » Gabinete Corsair® Carbide CC-9011056-WW [+]
- » Fonte Server ATX/EPS, PFC Ativo, 500W [+]
- » Cabeamento "Origami Design" para otimização de fluxo de ar [+]
- » Sem Monitor, teclado e mouse

Intel® Pentium® / Intel® Xeon® E3-1200V3:

Com processador Intel® Pentium® G-3260 (2-Core 3.3GHz, 3MB) : R\$ 17.250,00



Com processador Intel® Xeon® E3-1231V3 (4-Core HT 3.4GHz, 8MB) : R\$ 18.400,00



Customize seu Servidor



Windows Server 2012

Sistema Operacional MS Windows Server 2012 R2 Essentials OEM com 25 clientes, em português, por R\$2.495,00

Sistema Operacional MS Windows Server 2012 R2 Standard OEM com suporte a 2CPU/2VM, em português, por R\$4.585,00

Compare as versões Essentials e Standard

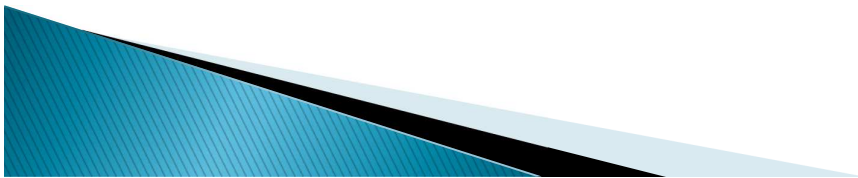


Source

- ▶ Course Text 1 Instructor's Support Materials
- ▶ <http://www.zdnet.com/>
- ▶ Western Digital Vídeo
- ▶ <https://youtu.be/B1MGsgsr9GE>

Checklist

- ▶ What is mirroring?
- ▶ What is striping?
- ▶ What is a parity bit?
- ▶ How do we use Hamming code to allow identification of a single error?
- ▶ List 5 levels of RAID
- ▶ What is Hybrid, Software, Hardware RAID?



The end!

Valeu galera!

