

### RAID

- RAID provides speed and/or redundancy
- RAID 0 (striping) provides speed
- RAID 5 and 6 (striping with parity) provides speed and redundancy
- RAID 5 can only lose one drive in the array; RAID 6 can lose two

RAID (Redundant Array of Inexpensive Disks) - Provides Speed and Data Redundancy



RAID 0 (Striping) - Minimum of 2 Drives

Save data quickly by saving files alternating between both drives

If you lose either drive, you lost everything



RAID 1 (Mirroring) - Minimum of 2 Drives (could also use 4)

Redundancy (Safety by saving a copy on the other drive)

Slower Process - we're asking the Hard Drive Controller to Save Twice

So, we like the Redundancy, but we also want Speed



## RAID 5 (Parity) - Minimum of 3 Drives

Let's say there's 4 Pieces to this File

1st Piece to 1st Drive; 2nd Piece to 2nd Drive,  
then using a Binary Math Machine, we multiply these 2 Pieces together  
to create a Parity value that's the same size of the 1st 2 Pieces  
on to the 3rd Drive.

If ANY of the 2 drives die, we could reverse the math of the Parity  
which gives us our Redundancy! (Protection).

3rd Piece to 3rd Drive; 4th Piece to 2nd Drive,  
then Binary Math Machine creates Parity on 1st Drive!!

RAID 5 - Good Speed & Redundancy of the Data!!!

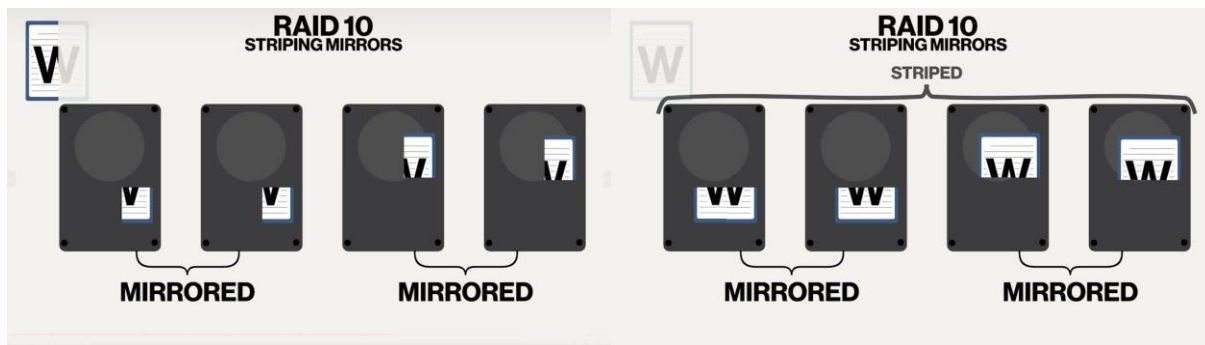
If you lose more than 1 Drive, you won't be able to Rebuild the Data



## RAID 6 - Minimum of 4 Drives

More Redundancy

Seems very similar to RAID 5, except that we can now lose up to 2 Drives  
because we're creating 2 Parity Files for each pair of Piece 1&2, and 3&4



RAID 10 (String Mirrors) - Minimum of 4 Drives (2 Mirrored Pairs)  
 Create a Mirror of Piece 1 on Devices 1&2  
 while Striping Piece 2 on Devices 3&4 (which are Mirrors).  
 Then, repeat this for Pieces 3&4

We can lose 1 Mirrored Drive on EACH side and be ok!  
 If we lose a FULL Mirrored Pair, we're out of luck.



RAID 0+1 - Minimum of 4 Drives (2 Striped Pairs)

We can lose 1 Striped PAIR on either side and be ok!  
 If we lose one on each side, we're out of luck.  
 (Notice this is the Opposite of RAID 10)

Can set this up is through Hardware & System Setup,  
 or through the OS & Software.

## Hardware RAID

- **Hardware RAID requires a controller to configure the RAID arrays**
- **Hardware RAID has its own BIOS that comes with a special system setup to configure the RAID array**
- **The completed array looks like a single drive to the operating system**

Video 45 (1001)

4 HDD's - AHCI Mode (Regular Hard Drives) to RAID Array

## Software RAID in Storage Spaces

- **Software RAID uses the operating system to configure the RAID array**
- **Windows comes with a powerful tool called Storage Spaces to configure advanced software RAID arrays**
- **Storage Spaces provides superb flexibility**

Video 26 talks about RAID's (Striped Volume), 2-Way & 3-Way Mirrors, and Pools  
Kind of confusing

Storage Spaces - Software RAID tool built into most copies of MS Windows  
Gives you a lot more flexibility, can do RAID5 (Parity), and more  
(Control Panel → System & Security → Storage Spaces)

Pool - Preassigned Group of Drives that work together

## Encrypting Mass Storage

- **File-based encryption encrypts files and folders;**  
**disk-based encryption encrypts entire drives**
- **Windows uses Encrypting File System (EFS) to encrypt folders and files**
- **Windows uses Bitlocker to encrypt entire hard drives**
- **Bitlocker requires a system with a Trusted Platform Module (TPM) chip**

Software feature built into the OS that allows you to....

File-Based Encryption - choose a specific File, or Folder, for encryption  
Use EFS

Disk-Based Encryption - choose a specific Drive for encryption  
Use Bitlocker

For Windows, we use...

EFS (Encrypting File System) - built into the NTFS

As long as the Drive is formatted with NTFS, you can use EFS

Right click file → Properties → Advanced (under Attributes) → Encrypt Contents

TPM (Trusted Platform Module) Chip holds a BitLocker Key

## Mass Storage Troubleshooting

- **Always back up important data before troubleshooting mass storage**
- **Use a mental process of installation to make sure all the installation steps have taken place**

Problems with Mass Storage

1) Back It Up! Even if it's just on a Thumb Drive

2) Mental Reinstall

If having an issue with a Drive you just installed,  
go through the process mentally from the ground up,  
attempting to remember that one step you forgotten

3) Triple Check

Check your process not once, or twice, but a third

## Troubleshooting Issues

RAID Not Found/RAID Not Working - Maybe it just wasn't installed before

- Is the RAID Controller Active?

- Do you have the right Drivers for that system?

- Check for any issues in the System Setup

- Make sure the Storage Devices are Installed Properly & have Power

If not working when it was working before.....

- Does the Hard Drive have Power? Plugged in?

- Was anything erased?

Read/Write Failure (for just a Single Drive) -

- Storage has a Life Span!

- Near the end, Read/Write becomes an issue!

- S.M.A.R.T. - This technology/detector is built into all Hard Drives

- We can query a Drive to find out its health

- We're ultimately going to Replace this Drive

- If we've been using a back up, this shouldn't be an issue!

Slow Performance -

- Usually for Slow Performance, one of the last places to blame is the HDD

- If it is a "Storage issue", it's usually actually a RAM issue,

- where we might not have enough and are using Virtual Memory

- Big clue for this is that Read/Write LED on the front of the computer

Loud Clicking -

- The "Click of Death" is Terminal. There's no way to get around this.

- Replace the HDD

Failure to Boot -

- Usually this is an issue with the Boot Order

- A Thumb Drive might be inserted which is taking priority

#### Drive Not Recognized -

The Drive itself might have a Formatting Issue

Reformat the Drive (This will wipe your drive clean!!)

If it was previously working fine, and now it's not,

this usually happens when uninstalling from one computer  
and reinstalling on another.

You need to Initialize the Disk before Windows will recognize it.

#### OS Not Found -

99% of the time it's because you messed up your Boot Process/Order!

System Setup to double check

#### Attempts to Boot to Incorrect Device -

Definitely the Boot Order!!

#### Continuous Reboots -

Rarely manifest from Mass Storage

Typically Corruption in the OS

Refer to Troubleshooting OS Videos

#### Mass Storage - Everything Runs on a Controller

Turning off a SATA Controller, or a RAID Controller,

or Turning Off USB when trying to read a Thumb Drive