HDD’s and SSD’s

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Hard Drive Types

2 Types of hard drives

- Hard disk drive (HDD)
- Solid state drive (SDD)

Hard drives store all of the programs, data and operating systems of your computer.

Note: IDE (Integrated drive electronics) refers to any hard drive with a built in controller. All hard drives are technically IDE drives, although we only use the term IDE when discussing ATA drives.

Platter – Based Hard drives (HDD)

- Composed of individual disks or “platters” Platter of food, this is starting to make me hungry, lunch time ;-
- Data is read / written by the head on the actuator arm. This is controlled by a servo motor.
- Platters are aluminium coated with a magnetic medium.
- Each platter has two heads one to read / write the top. One to read/write the bottom.
- Distance between the head and the platter is less than the thickness of a finger print.
- Platters aren’t to be exposed to air as dust on a platter would make a mountain on the disk and the drive wouldn’t be able to be read / written to properly.
- Have the form factors 2.5” and 3.5”
- Use PATA, SATA, SCSI, eSATA or USB

Data Encoding

- Hard drives store in a binary form.
- This is done by a magnetic spot representing one and a magnetic spot representing a 0.
- Hard drives store in tiny magnetic fields known as a flux.
- Flux’s can switch north / south polarity, back and forth through a process called flux reversal.
- Cylinders are where tracks of data are of the same diameter on each platter all the way through the drive.
- Track is any concentric circles on the platter. These tracks hold your data in sectors.
- A sector is 512 bytes of data found on a track.

Spindle Speed

- Hard drives have a rotational speed (RPM) very much like a car the higher the RPM the faster you go.
- While higher speed drives increase performance they can also cause a computer to overheat.
- Faster drives have been known to have a low life span.
Solid State Drive (SSD)

- Faster to boot and operate due to no moving parts
- No moving parts also means there is less power usage
- SSD’s use non-volatile memory chips
- Form factors of 1.8”, 2.5” or 3.5”
- Use PATA, SATA, SCSI, eSATA or USB
- SSD’s are more expensive than original platter-based HDD’s. Less expensive SSD’s typically implement less reliable multi-level cell (MLC) memory technology in place of the more efficient single-level cell (SLC) technology to cut costs.

Parallel and Serial ATA Interfaces

- ATA drives are often referred to IDE drives (Integrated Drive Electronics)
- ATA stands for Advanced Technology Attachment. This was released in 1990’s
- SCSI (Small computer system interface) pronounced Scuzzy; this is the only other interface that has any relevance to HDD’s.

ATA drives come in two “flavors”

- PATA (Parallel ATA) drives. These drives send data in parallel on a 40 or 80 wire data cable.
- SATA (Serial ATA) drives. These drives send data in serial using only one wire for data transfers.

ATA – 1

- First computer to include BIOS support for hard drives was the 80286-powered IBM PC AT. This supported up to two physical drives, each drive could be up to 504 MB. Far larger than 5MB and 10 MB Drives that were around at that time. Although built-in support for hard drives was handy, installing, configuring and trouble shooting of a HDD was difficult.
- To sort this WD and Compaq developed ATA (AT Attachment) interface.
- ATA specified a cable and a built-in controller on the drive.
- This stopped the need to replace the BIOS on installing a new HDD.
PIO and DMA

PIO

- Programmed Input / Output
- Nothing more than the traditional I/O addressing scheme this is where the CPU talks directly to the hard drive via the BIOS to send and receive data.
- Three speeds called PIO modes were initially adopted:
  - PIO mode 0: 3.3 MBps
  - PIO mode 1: 5.2 MBps
  - PIO mode 2: 8.3 MBps
    (Mega Bytes per second)

DMA

- DMA modes define a method to enable the hard drives to talk to RAM directly.
- (Single-Word DMA) – Old style DMA commands were slow and the resulting three ATA single-word DMA modes were slow:
  - Single-word DMA mode 0: 2.1 MBps
  - Single-word DMA mode 1: 4.2 MBps
  - Single-word DMA mode 2: 8.3 MBps
- When a computer booted up the BIOS queried the hard drive to see what modes it could use and then it auto selected the fastest mode.

ATA Physical Connections (PATA)

- 40 Pin ribbon cable that plugs the HDD directly into the motherboard.
- The 40 pin cable has a stripe down one side that denotes pin 1
- 2 drives (Max) could connect per each IDE connector.
- ATA identifies two drives as master and slave. You can set the drive as master / slave by the jumper on the back of the drive normally alongside the PATA data cable.
ATA – 2

- In the 1990’s a new standard called ATA-2 was born bringing many improvements over ATA – 1.
- This was also known as EDIE (Enhanced IDE). This was no more than a marketing term by Western Digital. Although the entire industry used the term.
- Brought higher capacities.
- Could handle a second IDE controller. Which allowed 4 devices.
- Improved data throughput due to the addition of two new PIO modes and a new type of DMA called multi-word DMA:
  - PIO mode 3: 11.1 MBps
  - PIO mode 4: 16.6 MBps
  - Multi-word DMA mode 0: 4.2 MBps
  - Multi-word DMA mode 1: 13.3 MBps
  - Multi-word DMA mode 2: 16.6 MBps

- Added an extension to ATA called ATAPI (Advanced Technology Attachment Packet Interface). This added support for non-hard drive devices such as CD-ROM and tape drives to connect to the PC via the ATA controller. The only difference between HDD’s and every other type of drive that attaches to the ATA controller is how the drive get’s BIOS support. HDD’s get support through the system BIOS where as non-HDD’s get it through the operating system drivers.
- Added LBA, Logical block addressing. In logical block addressing, only one number is used to address data, and each linear base address describes a single block.
  ^ Don’t worry we aren’t going in to detail about this as it isn’t really needed as far as I can tell.

ATA – 3

- Added S.M.A.R.T (Self-Monitoring, Analysis and Reporting Technology). This helps predict when a hard drive is going to fail by monitoring the hard drive’s mechanical components. It is though complex, imperfect and hard to understand. Only a few utilities can read the S.M.A.R.T. Normally all HDD manufacturers have a S.M.A.R.T utility to check their type of HDD.
ATA – 4

- Introduced a new DMA mode called Ultra DMA that is now the primary way a HDD communicates with a PC. Ultra DMA uses DMA bus mastering that is was faster than were possible with PIO or old-style DMA:
  - Ultra DMA mode 0: 16.7 MBps
  - Ultra DMA mode 1: 25.0 MBps
  - Ultra DMA mode 2: 33.3 MBps

INT 13 Extensions

The original ATA – 1 standard allowed for HDD’s up to 137 GB. It wasn’t the ATA standard that caused the 504 MB limit. The BIOS (Old AT Bios) was the cause of this. LBA was a work – around lie that allowed us to get to 8.7 GB. Finally in 1994 Phoenix Technologies created a new set of BIOS commands called Interrupt 13 (INT 13) extensions that allowed the system to handle up to 137 GB.

Since this every system made since 2000 supports INT 13

ATA – 5

- Ultra DMA had an upgrade since it was a huge hit:
  - Ultra DMA mode 3: 44.4 MBps
  - Ultra DMA mode 4: 66.6 MBps
- Ultra DMA mode 4 was so quick that that ATA – 5 defined a new ribbon cable which had 80 wires instead of 40. This cable also defined (Colour coded) certain connectors to show which is master and which is slave. This mode was known also as ATA/66
- Normally this is blue for master and grey for slave.

ATA – 6

- Industry proposal adopted called Big Drive. This pushed the HDD’s limit to 144 petabytes. (150,994,944 GB). This was then renamed to ATA / ATAPI-6 or simply ATA-6.
- This was basically just a 48-bit LBA.
- Enhanced block mode, Allowed drives to transfer up to 65,536 sectors in one chunk. Instead of the 256 sectors on previous HDD tech.
- Yeah you’re tired now, but wake the fuck up.
- Also introduced Ultra DMA mode 5 putting the data transfer rate up to 100 MBps. This is more commonly referred to as ATA/100 and requires the 80 wire cable.
ATA – 7

- Brought two new innovations. Parallel ATA Ultra DMA modes and the revolutionary addition was SATA (serial ATA).
- Ultra DMA mode 6 (ATA/133) runs at 133 MBps but uses the same cables as Ultra DMA 66 and 100
- Serial ATA was introduced.

SATA

- SATA devices send data serially, compared to PATA which was parallel, this results in way less wires, SATA requires 7 wires compared to the 80 pin/40 pin on PATA.
- Hot swapping was allowed. (You don’t need to power down the computer when replacing or adding a SATA disk)
- SATA can have longer cables. 1 meter instead of 18 inches.
- SATA does not use the master / slave concept. Each drive connects to one port so no daisy chaining drives.
- No max amount of drives.
- Currently has 3 specifications:
  - SATA 1: 1.5 GBps (150 MBps Throughput)
  - SATA 2: 3 GBps (300 MBps Throughput)
  - SATA 3: 6 GBps (600 MBps Throughput)
- Is backward compatible with PATA if you use a SATA Bridge, this SATA Bridge is a tiny card that is plugged in to the back of the PATA drive.
- Windows Vista + support AHCI (Advanced Host Controller Interface). This unlocks some certain features:
  - Hot swapping
  - Native command queuing and more
  ^This is a disk-optimization feature for SATA drives which enables faster read and write speeds.

AHCI is implemented at CMOS level and needs to be enabled before you install the operating system. Enabling it after installation will cause a blue screen.

- eSATA (External SATA) extends SATA to external devices.
  - Can use shielded cable lengths up to 2 metres long
  - Uses same SATA bus speeds, which is faster than USB 3.0 (If 6 GBps eSATA)
  - Some laptops have eSATAp ports which combines a USB connection with an eSATA connection. You can connect an eSATA, eSATAp and USB connection to this port. eSATAp allows you to connect a drive using a single cable to power it and send/receive data.
SCSI ↔ Yes it’s still here…… (ugh)

SCSI pronounced scuzzy. Stands for small computer system interface.

- Used in specialized server machines and enthusiasts.
- Used in a wide variety of hardware such as HDD’s, printers, external drives etc.
- SCSI could be daisy chained together:
  - Each device would have an ID to distinguish it from other devices. (The ID can range from 0 – 15)
  - You don’t need to have the numbers in any order; you can skip numbers or use random numbers as long as two devices don’t have the same ID. You can have two devices with the same number IF using two controllers, one on each controller.
  - The end of a SCSI chain must be terminated with either jumpers found on the device or a terminator connector. Termination must be at the end of the daisy chain, you can’t terminate in the middle of a page.

- Internal SCSI devices connect to the SCSI adapter using a 68 pin ribbon cable. External devices use a 50 pin high-density (HD) connector. Higher-end SCSI devices may also use a 68 pin HD connector and may have an input and output SCSI connector so you can daisy chain them. The external SCSI connectors are D-Shaped so you can’t plug them in the wrong way.
  ^ Some early versions of SCSI used a 25 pin connector. This connector was more popular on Apple devices. Though it was used on SCSI zip drives.

RAID

RAID (Redundant Array of Independent (or inexpensive) disks), is a method of securing data and increasing speeds of data transfer by using multiple disks.

Pineapples <- Just checking that your still awake.

There is multiple types of RAID:

RAID 0: Disk striping

Disk striping requires at least two drives. It does not provide redundancy to data. If any one drive fails all data is lost. Also note that if you had 2, 120 GB drives your total capacity would become 240 GB as striping uses both drives to store bits of data so reading and writing becomes faster increasing your computers performance.

RAID 1: Disk Mirroring / Duplexing

Disk mirroring is a process where one hard drive is mirrored to a secondary hard drive on the fly as the computer is being used. RAID 1 is great for data protection as if one drive fails you know it’s being mirrored on to the second hard drive. This doesn’t bring any performance benefits.
So this time instead of adding the capacity together, if you had 2, 120 GB drives your total capacity would be 120 GB.

**RAID 2: Disk striping with multiple parity drives**

RAID 2 was a weird RAID idea that never was used, don’t bother with it. They say this is where Stig was born.

**RAID 3 and 4: Disk striping with dedicated parity**

RAID 3 and 4 combined dedicated drives with dedicated parity drives. The differences between the two were kind of trivial. Unlike RAID 2, this quickly turned in to the idea of RAID 5.

**RAID 5: Disk striping with distributed parity**

Instead of dedicated data and parity drives, RAID 5 distributed data evenly across all drives and left a bit of each drive with a bit of parity information, this was the fastest way to provide data redundancy. This is the most common application of RAID today.

So if we had 4x 120 GB drives we’d keep around 120 GB of parity (parity is normally equal to one drive, this data is spread across all the drives.) The rest of the space available will become the capacity of the drive: 360 GB.

If a drive fails the parity should be able to recalculate and provide information enough to recover your files to put on a new drive when you run a rebuild of the RAID array.

**RAID 6 Disk striping with extra parity**

If you lose a hard drive in a RAID 5 array your data is at great risk until you replace the bad hard drive and rebuild the array.

RAID 6 is the same idea as RAID 5 with extra parity information, this requires at least 5 drives, but in exchange you can lose up to two drives at the same time. RAID 6 is quickly becoming more popular.

**More about RAID**

RAID is one of the most handy solutions for servers and other systems as it can one keep your data safe and two, more than double your storage performance by using multiple drives. RAID arrays can be built and used with two different systems

- **Hardware RAID**
  - Requires a dedicated RAID controller, some motherboards have them built in, if not you will have to purchase a PCI or some other expansion card.
  - Doesn’t strain the CPU and use RAM as it will have its own processor and RAM dedicated to RAID and it will increase performance of the RAID array.
  - More expensive as you may have to buy a dedicated RAID card.
 Normally you set this up in the BIOS before booting into windows, this may be on the system setup if your motherboard has a built in RAID system or on BIOS of the RAID controller expansion card just after BIOS and just before Windows normally.

Software RAID

- Can use different software to use software RAID, the main software would be Disk Management found in Windows XP upwards.
  - Note, With Windows XP and Vista you can only do RAID 0, while Windows 7 supports 0 and 1.
- Has a decrease in performance as software RAID uses the CPU and System RAM instead of dedicated RAID hardware.
- Always try and use hardware if performance is a critical component of the system.

I know you’re probably sitting here thinking oh god…. Not more, but I promise you guys it’s the last section of this chapter. Honestly I think I should start writing my own book as it’d be way easier to read and understand (in my view) than the 1500 page book we are studying.

BIOS Support, Configuring CMOS.

I was about to copy the study book we are reading and write “And Installing Drivers”, but I noticed, that you honestly don’t need to learn about installing drivers again, also the book has nothing on Installing HDD drivers as Modern HDD’s don’t need drivers anyway as the BIOS will support them. (Dumb ass book).

The only time you may need to install a driver or firmware, is when installing a SCSI drive, this is normally done on the host adapter.

- On installing a new HDD make sure:
  - Your bios does not have the SATA controller disabled for the specific port you are using, a lot of the time these are left enabled for the system to auto detect a new HDD, but most Dell and other proprietary motherboards leave them disabled and bitch at you till you enable them.
  - The cables are fully plugged in, especially the case with PATA cables.
  - In the case of a PATA HDD, make sure your jumpers are set correctly, Master is used for your operating system normally and slave for another HDD or a CD / DVD drive.
After installing a HDD the system BIOS should detect the HDD and auto configure it this is called Autodetection. SATA changed autodetection slightly as SATA has no master slave or even primary and secondary controller, motherboards use a SATA numbering system and every motherboard uses its own numbering system. The common term for this would to call each port a channel for the controller.

- The first boot device would be known as channel 1
- The second device would be channel 2.
- So on and so forth.

*Wake the feck up before I slap you.*

**Boot Order**

For a computer to start up and do something you need an operating system.

- Older PC’s in the 1980s and early 1990s required the boot drive to be on the primary master.
- BIOS makers eventually allowed you to put the OS on any of the four drives and set the CMOS to boot off a specific drive.
- You can boot off multiple devices, From CD’s, DVD’s to HDD’s and USB thumb drives, there is many other boot devices but the four I listed are the main devices.
- You can set the boot order within the system setup utility, if you can’t see it, make sure you check advanced settings. It may also be named Boot device priority.
- Note: If a user gets an Invalid boot disc, the boot order is wrong or the computer is trying to boot from a floppy, CD or other media, remove all drives and disks and reboot.