Storage Devices & Fault Tolerant Storage

How to survive a PC Disaster

Types of Internal PC Storage

- Laptops, limited by size:
  - Hard Disk Drives (HDD), 2 ½ inch
    - Small, physical disk.
    - Long term retention
    - Shock damage potential
    - Medium read/write update speed
    - Inexpensive
    - (1TB Seagate shown)
  - Solid State Drives (SSD) Drives, 2 ½ inch
    - Small, physical disk.
    - Medium term retention
    - Little Shock damage potential
    - Fast read/write update speed
    - Not Inexpensive
    - (1TB Seagate shown)

- Desktops, various Case Sizes
  - Case sizes Vary
    - Mini – Limited disks, used for
      - Processor Speed applications
      - Remote Desktops
    - Standard – Larger Storage ability
      - Multiple Disk Capability
      - WORM type devices (**W**rite **O**nce **R**ead **M**any – e.g.DVD)
      - Larger working memory
    - Large Cases
      - Large Disk Capability
      - Multiple internal storage types
      - Higher Cooling ability
      - Multiple Processors - servers

- Desktops Internal Storage:
  - Disk Drives, 2 ½ inch
  - SSD Drives, 2 ½ inch
  - Hard Disk Drives (HDD), 3 ½ inch
    - Large capacities, lower price
      - E.g. 4TB £57
    - Very Large Capacities available (14TB drives), lower cost
      - E.g. 14TB £328, SSD 8TB £540
  - Multiple drives and types on one machine:
  - Data Resilience/Tolerant to failure
    - RAID – Later in talk
  - Plus external storage devices (BD, DVD, CD, Tape Streamers (now not seen)
- Special Motherboard Storage
  - NVMe (nonvolatile memory express)
    - Not a “Disk Drive” attachment but “On Motherboard” superfast SSD

Types of External PC Storage

- USB HDD:
  - Small USB connected drives
    E.g. 120GB HDD up to 2 TB or more
  - USB Connection Device
    (for SSD or HDD).
    Note USB may reduce access speeds
    Example is to recover disks,
      can buy cased units
  - Reasonable Cost
  - Shock Failure

- USB SSD
  - As per HDD but faster read/write speeds
  - Speeds may be limited by USB connection
  - Cost not insignificant
  - Robust
  - Data can be lost due to magnetic interference
- USB Sticks
  - Small
  - Easy to Carry
  - Reasonable Cost
  - Can lose data over time/, magnetic interference
  - Storage size small to medium (1GB - 250GB)
  - Costs medium to high
  - Normally slower than SSD

- SD Card
  - Various Sizes
    - 1GB – 2TGB. Usually smallest is 16GB, 512GB larger
  - Various Transfer Speeds
    - 5MB/s – 300+MB/s
    - Various Prices depending on size and speed
    - £4 - £1,300
  - Various Uses
    - Phone Storage (slow transfer) high resolution

      Digital Cameras (fast Transfer)
  - Can be used for Storage
    - Medium Speed (10 MB/s, 128GB, Kingston £12)
    - High Speed (170MB/s, 128GB, Sandisk, £23)
    - Very High Speed (300MB/s, 128GB, Sandisk, £202)

RAID Redundant Array of Independent (Inexpensive?) Disks

- RAID (in the simplest terms)
  - An array of multiple disks providing various levels of resilience (fault tolerance)
  - RAID Levels:
    - 0 – Striping. Multiple Disks are striped to appear as one logical drive that then can have multiple accesses (i.e. each physical disk can be accessed at the same time), No redundancy, if one disk fails the logical drive fails. Faster access speed.
    - 1 – Mirroring. An array of disks where each physical disk has a second disk that mirrors the first. If one disk fails then the other contains the data. Normally allows for a failed disk to be replaced, and the data salvaged back to be again a mirrored pair, without powering off the logical drive. Speeds up reads as both disks can be read but delays writes slightly as both disks have to be written to
    - Others, 2, 3, 4, 5, 6 and 10. Various options of the above using mirroring and striping to provide increased speed and redundancy.
  - Why use it?
    - HDDs have a failure rate of about 2.5% p.a. so RAID provides a more secure storage option. SSDs have a .5% failure rate so more resilient (albeit expensive) but can still fail.

- Network Attached Storage (NAS)
  - This is an array of disks (usually HDD but can be SSD) with normally Raid 1 applied. These provide a separate Network Drive with secure storage separate from the PC itself.
  - It runs as per a single drive but access via the network. Has it's own processor to manage the drives and access.
  - Provide a secure drive away from the PC, not affected by PC failure and can be access by any PC/Users.
  - The internal network speed can reduce the access (i.e most local networks are 1Gb or at worst 100Mb, disk access can be 250+MB for serial reads or writes)
  - FYI 1MB (mega byte) is approximately 10Mb (mega bit)
- Cloud Backup
  - Put simply this is a NAS solution provided by a separate company remotely on their network. The speed is restricted by the Internet connection speed to their network. So download could up to 70Mb/s with upload 7-13Mb/s. Fibre to the house speeds can provide 250-300Mb/s

Storage Device Speeds

- Measured Speed
  - HDD (Two Banks Measured)
    - Read - Write Speed 200 – 250 MB/s
    - Read - Write Speed 325 – 180 MB/s
  - SSD
    - Read - Write Speed 560 – Write 515 MB/s
  - NVMe
    - Read Speed 3,400 – Write 2,700 MB/s (3.4 – 2.7GB/s)
- Measured on a Desktop PC:

  Ryzen 7 3700X 8 Core CPU (16 Threads, 3.7GHz)

  32GB 3200Mhz RAM

  MSI B450 Pro Max Motherboard

  GTX 1650 OC 4GB GPU

So what are the Backup Options

- 1 – Cloud
  - Costs money but usually secure and resilient to loss. Very slow to back up.
- 2 – NAS
  - Needs separate NAS server (2 -3 4 or more drives), NAS drive about £150 – £200 plus disks.
  - Faster to backup and can be done with PC left on outside of normal hours
- 3 - USB HDD
  - If not raided then not resilient but could do double backups
- 4 – USB SDD
  - As per 3 but faster and lower failure rate, higher price
- 5 – Other remote storage
  - Smaller, less convenient but cheaper

- So it depends what data you have to backup, and more importantly what data you want to guarantee to be safe.
  - My own example may seem extreme:
    - I have a 18 MPixel camera, take pictures as Canon RAW format, i.e. every pixel has it's own piece of stored data. I amend photos and then create JPGs that can be viewed on most devices (TV's Phones, etc.)
    - Each Picture takes some 20MB of storage (older, less techy cameras, are much smaller) plus a 5-10KB JPG. I have some 3,000+ high res pictures, in total pictures and videos take over 1.2TB of storage
    - I also have been a charity trustee for a number of years and so need to store this and my personal and family date securely for a number of decades.
    - My PC has 12TB of HDD arranged as Two Logical drives of 3TB (each having 2*3TB drives Mirrored as Raid 1).
    - I have a NAS unit of 2TB (2*2TB drives Raid 1)
    - I use BT Cloud as a final backup for the most important data of 1TB
    - A full backup to the NAS takes about 1 ½ - 2 days continuous and to BT (about 800GB) 3 - 5 days
    - The NAS has a Delta update each week that takes under 1 hour, BT is about each fortnight as it takes about 1 night
  - When on Holiday I take a Mini PC to copy the day's photos to. This is just in case someone steals my camera. The Camera and lenses are very pricey but are insured. The photos are not and the cost of taking them again is up to 10 times the insured camera.