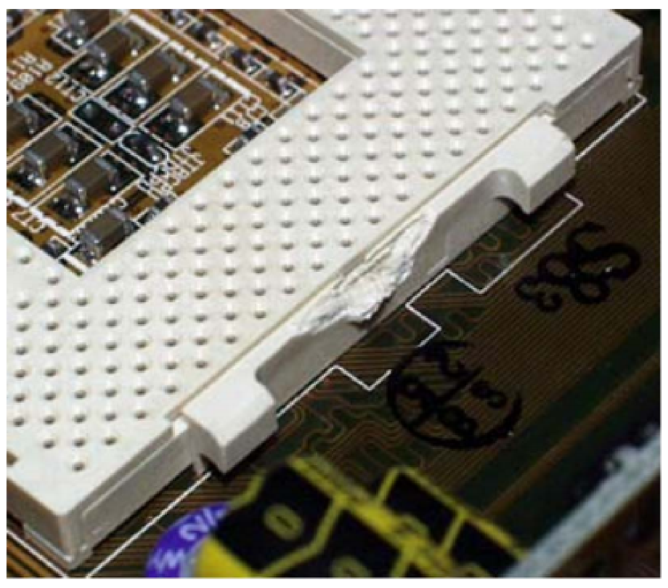
Week 8: Failure statistics

Warranties

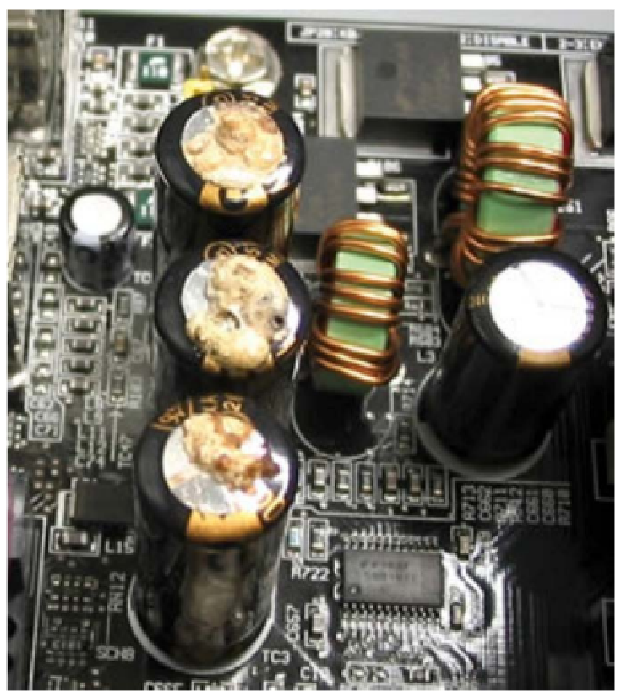
- Reliability data is used by manufactures to calculate the length of warranty to offer
  - but a long warranty doesn't always mean a better product
    - other factors such as the resulting market reputation of a long warranty come in to the business decision of setting a warranty period
- however if MTTF/MTBF and price for two components is equivalent, choosing the one with the longer warranty is a prudent choice

Component failure

- Chip failure: thermal runaway is a risk for CPUs
  - CPUs produce a lot of heat in a small area
- Thermal Runaway
  - If silicon is heated above 160 C, resistance decreases allowing more current to flow, producing even more heating
  - Vicious cycle, until eventually the silicon melts
- Modern CPUs have inbuilt thermistors to measure temperature
  - Slow down/shut down as temperature increases
- Cooling failure
  - Fan failure will cause components to overheat and fail
  - Tower cases have a vertical motherboard, so the heatsink is at right angles to the ground; gravity can pry it right off its mounting point (chassis failure) - loose heatsink retension

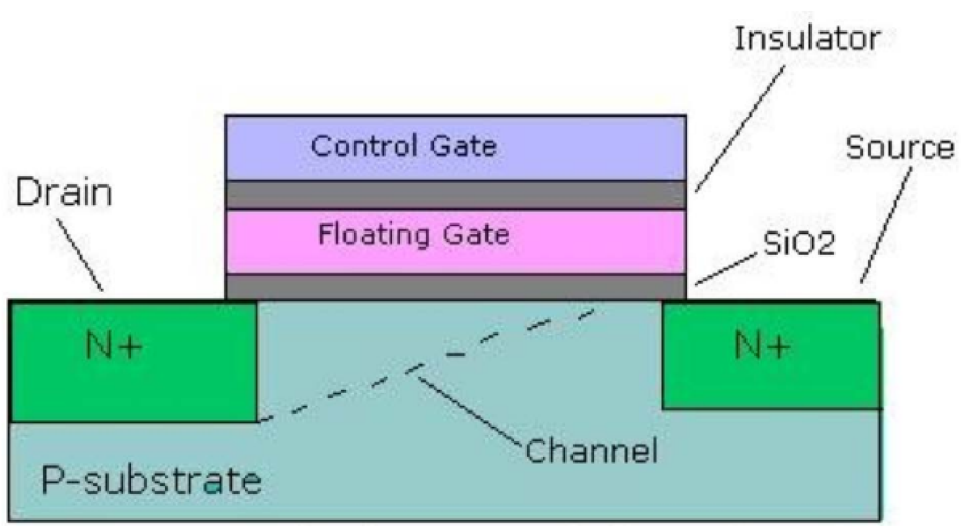


- Discrete component failure: e.g. capacitor failure
  - capacitors used on motherboard and power supply to store and smooth out power
  - some capacitors can leak and fail
  - large problem in the mid 2000's (the **Capacitor Plague** (https://en.wikipedia.org/wiki/Capacitor_plague) event)

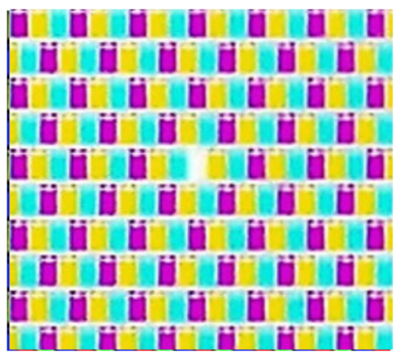


- Storage device failure
  - Magnetic and optical disks are mechanical and can suffer many types of mechanical failure:
    - bearing wear
    - motor failure
    - loss of alignment
    - foreign objects/debris
    - **head crashing** (https://en.wikipedia.org/wiki/Head_crash)
    - disc shattering

- Solid state storage
  - non mechanical, so more robust (e.g. dropping it won't break it)
  - flash memory cells can only be written a limited number of times
  - insulation between transistor components slowly eroded by write operations, until the transistor fails



- LCD failure
  - Cold cathode fluorescent light (CCFL) LCDs are much more failure prone than LED backlit LCDs
  - CCFL tube can break so no light available for LCD to filter
  - CCFL inverter necessary to excite gas in CCFL. Inverter failure causes backlight failure
    - Failure at manufacture of control electronics for twisting liquid crystal can cause a subpixel to be stuck on or off
    - Damage to delicate control lines between LCD control circuit and LCD subpixel matrix can result in lines being on/off across the display



Reliability strategies

- Chip failure risk reduced via strategies such as:
  - Auto-configuration
    - Chip knows default settings for communicating with other components, reducing the amount of (error prone) human configuration required that could lead to failure
  - Thermal tripping
    - inbuilt thermistor shuts down chip if it overheats
  - Thermal throttling
    - processor slows down its clock speed if overheating, reducing heat generation
  - System designer can also [*underclock*](https://en.wikipedia.org/wiki/Underclocking) (https://en.wikipedia.org/wiki/Underclocking) chips
- Cooling failure risk can be reduced by:
  - Using a heatsink/fan rated for chip heat production
  - Correctly mounting heatsink/fan
  - Using good quality fans
  - Include extra headspace in case for heat dissipation if fan speed is reduced
  - Using motherboards that can detect failure of a fan (common now)
- Discrete component failure risk: e.g. capacitor failure
  - using technologies with lower failure rates
  - e.g. solid state capacitors instead of liquid dielectric capacitors that could leak
- Mechanical storage device failure risk:
  - Hark disks reduce head crash risk by having automatic head parking , and also park heads if accelerometers detect a drop
  - [SelfMonitoring, Analysis and Reporting Technology](https://en.wikipedia.org/wiki/S.M.A.R.T.) (https://en.wikipedia.org/wiki/S.M.A.R.T.) (SMART) system monitors performance for signs of impending failure

ID	Attribute Name	Value	Raw Value	Worst	Threshold	Status
1	Raw read error rate	65	6A5FF8E	57	6	65%
3	Spinup time	97	0	95	0	97%
4	Start/Stop count	95	1661	95	20	
5	Reallocated sector count	100	0	100	36	100%
7	Seek error rate	87	236B5389	60	30	87%
9	Power-on hours count	75	58CB	75	0	
10	Spinup retry count	100	0	100	97	100%
12	Power cycle count	100	1A8	100	20	
194	Temperature	40	28	68	0	
195	Hardware ECC recovered	65	6A5FF8E	57	0	
197	Current pending sector count	100	0	100	0	
198	Offline scan uncorrectable count	100	0	100	0	
199	UDMA CRC error rate	200	0	200	0	100%
200	Write error rate	100	0	253	0	
202	Data Address Mark errors	100	0	253	0	

- Mechanical storage device failure risk cont.
  - CD and DVD drives are able to sense an imbalance in the disc being spun to prevent disk shattering
- Solid state storage failure risk:
  - By spreading write operations over the solid state drive, the drive controller can prevent one area failing prematurely due to overuse
  - By providing extra flash memory (over-provisioning), worn out cells can be disabled and extra cells used instead
- LCD display failure risk:
  - Industry moving to LED lighting
  - Manufacturing improvements have reduced stuck subpixel rate

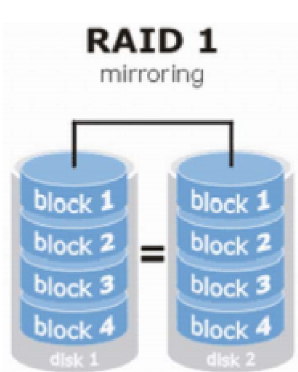
Error correction & redundancy

- Component failure or error can't always be prevented
  - Error correction and redundancy are two techniques for handling errors or component failure after it has occurred
- Error correction:
  - example: Error Checking and Correction (ECC) memory
  - advanced ECC memory spreads the Hamming code over multiple memory chips
  - failure of an entire chip results in loss of 1 bit, which is reconstructed from the remaining Hamming checksums
  - overprovisioning of memory chips allows failed chip to be disabled and replaced by spare

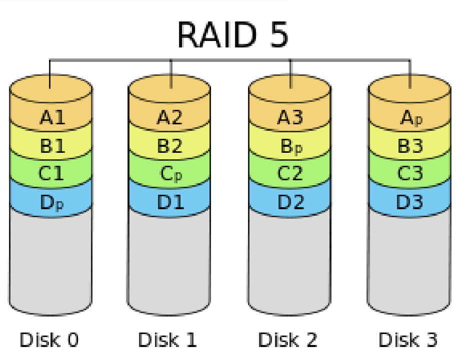
- Redundancy – e.g. power supply redundancy

- Redundant Array of Independent Disks (RAID)
  - distributes data over multiple hard disks
  - various configurations (levels)

Raid 0: Striping: interleaving blocks of data over multiple dives Improves performance, but decreases reliability



- Raid 1: Mirroring: replicating the data of one physical disk, onto another
  - Increases reliability at cost of doubling hardware



- Raid 5: Parity: similar in principle to advanced memory EEC
  - Data stripped
  - Error correcting code (e.g. Hamming) applied to each disk
  - Data on failed disk can be recovered using remaining checkbits
  - Parity data only takes up relatively small amount of disk