Iron Law of Performance

$$CPU_{EXEC\ TIME} = \frac{instructions}{program} * \frac{cycles}{instruction} * \frac{time}{cycle}$$

Iron Law with Unequal Instruction Times

$$CPU_{EXEC\ TIME} = \left(\sum \frac{instructions}{program} * \frac{cycles}{instruction}\right) * \frac{time}{cycle}$$

CPI (Overall or Average)

$$CPI = CPI_{program} + \frac{mispredictions}{instruction} * \frac{penalty}{misprediction}$$

Speed Up:

$$SpeedUp = \frac{Old\ CPU_{EXEC\ TIME}}{New\ CPU_{EXEC\ TIME}} = \frac{New\ Throughput}{Old\ Throughput} = \frac{Old\ Latency}{New\ Latency}$$

Amdahls Law

$SpeedUp = \frac{1}{(1-P)+\frac{P}{N}}$ Note: P must be a percent of execution time, not a percent of instructions/cycles.

AMAT

$$AMAT = hitTime + missRate(missPenalty)$$

$$missTime = hitTime + missPenalty$$

$$AMAT = hitRate(hitTime) + missRate(missTime)$$

$$AMAT = L1\ hite\ rate + L1\ miss\ rate * L1\ miss\ penalty$$

$$L1\ miss\ penalty = L2\ hit\ time + L2\ miss\ rate(L2\ miss\ penalty)$$

$$L2\ miss\ penalty = L3\ hit\ time + L3\ miss\ rate(L3\ miss\ penalty)$$

$$GlobalHitRate = 1 - \frac{\#\ of\ Misses\ this\ cache\ level\ has}{\#\ of\ all\ Memory\ Accesses}$$

$$LocalHitRate = \frac{\#\ of\ Hits\ this\ cache\ level\ has}{\#\ of\ accesses\ to\ this\ cache\ level}$$

Fault Tolerance

Reliability = MTTF = average time a system works until a part of it fails

Availability = MTTF / (MTTF + MTTR) = percent of time a system is working correctly

For all RAIDs: $f_1 = failure\ rate\ of\ a\ single\ disk, f_N = failure\ rate\ of\ N\ disks = N * f_1$

$MTTF_N = MTTDL_N$

RAID0

$$MTTDL_1 = \frac{1}{f_1}, \quad N\ disks: MTTDL_N = \frac{MTTF_1}{N}$$

RAID1

$$MTTDL_1 = \frac{1}{f_1}$$

$$2\ disks\ (no\ disk\ replacement) MTTDL_2 = \frac{MTTF_1}{2} + MTTF_1$$

$$2\ disks\ (with\ disk\ replacement) MTTDL_2 = \frac{MTTF_1}{2} * \frac{MTTF_1}{MTTR_1}$$

RAID 4/5

$$N\ disks\ (no\ disk\ replacement) MTTDL_2 = \frac{MTTF_1}{N} + \frac{MTTF_1}{N-1}$$

$$N\ disks\ (with\ disk\ replacement) MTTDL_2 = \frac{MTTF_1}{N} * \frac{MTTF_1}{N-1} * \frac{1}{MTTR_1}$$

Many Core Challenges

$$power = Cv^2f$$

$$f_{new} = f_{old} * \sqrt[3]{\frac{old\ number\ of\ cores}{new\ \ number\ of\ cores}}$$

$$exe_{new} = (exeTime\ speedup * old\ exeTime) * frequencySpeedup$$

$$exe_{time\ speedup} = \%ofTimeWeCanUseXCores * \frac{1}{X} + \cdots +$$