COA TUTORIAL

Q1: A program runs on a 3 GHz processor with an IPC of 1.5. The program has 5 billion instructions. What is the execution time?

Answer:

Execution Time = Total Instructions / (IPC×Clock Speed)
Execution Time = 5×10^9 / (1.5×3×10^9) = 5 / 4.5 ≈1.11 seconds

Q2: A system has a single-threaded portion that takes 30% of the time. If the parallel portion is speed up by a factor of 5, what is the effective speedup?

Answer:

1 / (1 - P + P / N)

Speedup = 1 / (0.3 + 0.7 / 5) = 1 / (0.3+0.14) =1 / 0.44 ≈ 2.27

Q3: A parallel program has 85% of its workload that can be parallelized. The parallel portion is executed on 8 cores. However, there is a 10% overhead for communication between cores. What is the effective speedup of the program?

Answer:

Effective Parallel Portion = 0.85 × (1 − 0.10) = 0.765
Speedup = 1 / ((1 − 0.765) + 0.765 / 8) = 1 / (0.235 + 0.095625) = 1 / 0.330625 ≈ 3.02

Q4: A CPU has a base CPI of 1.5 when all memory accesses hit in the cache. However, there is a 10% cache miss rate, and each cache miss incurs an additional 100 clock cycles. If 25% of the instructions involve memory access, what is the effective CPI of the CPU?

Answer:

Effective CPI = Base CPI + (Miss Rate × Miss Penalty × Memory Access Percentage)
Effective CPI = 1.5 + (0.10 × 100 × 0.25) = 1.5 + 2.5 = 4

Q5: Memory operations currently take 30% of execution time. . A new widget called a “cache” speeds up 80% of memory operations by a factor of 4 . A second new widget called a “L2 cache” speeds up 1/2 the remaining 20% by a factor of 2. What is the total speed up?

Answer:

Initially: Not memory = 0.7
L1: 0.3 * 0.8 = 0.24
L2: (0.3 * 0.2) / 2 = 0.03
no boost = 0.03
Total = 1

Later:

Not Memory = 0.7
L1: 0.24 / 4 = 0.06
L2 : 0.03 / 2 = 0.015
No boost = 0.03
Total = 0.805
Speedup = 1 / 0.805 = 1.24

Q6: A processor can execute 2 threads in parallel, each with a latency of 50 milliseconds. Due to overhead, the execution time increases by 20% when both threads are executed in parallel. Calculate the latency and throughput for both serial and parallel execution modes.

Answer:

- **Serial Execution:**
  - Latency = 2 × 50 ms = 100 ms
  - Throughput = 2 / 100 ms = 0.02 tasks / ms
- **Parallel Execution:**
  - Latency = 50 × 1.20 = 60 ms
  - Throughput = 2 / 60 ms ≈ 0.033 tasks/ms

Q7: A processor can operate at 2 GHz consuming 100 watts or at 1 GHz consuming 50 watts. If a program takes 5 seconds to complete at 2 GHz, how much energy is saved by running the program at 1 GHz?

Answer:
At 2 GHz:

Time = 5 s, Power = 100 W, Energy = 100 × 5 = 500 J At 1 GHz:

Program time = 10 seconds (because speed is halved)

Energy = 50 × 10 =500 joules

No energy is saved; both scenarios use the same energy.

Q8: A new compiler optimization reduces the instruction count of a program by 25% but increases the CPI by 10%. If the original program has an IPC of 2 on a 3 GHz processor, calculate the new execution time after optimization, given the original execution time was 4 seconds.

Answer:

Original Execution Time:

Instructions = 2 × 3 × 10^9 × 4 = 24 × 10^9 (#insn = IPC × f × ET)

CPI=1 / 2=0.5

New Instruction Count = 0.75 × 24 × 10^9 = 18×10^9

New CPI = 1.1 × 0.5 = 0.55

New Execution Time:

Execution Time = 18 × 10^9 / (0.55 × 3 × 10^9) ≈10.91 seconds

Q9: A processor consumes 60W of dynamic power at 2.2 GHz and 1.3V. If the frequency is reduced to 1.8 GHz and the voltage is scaled down to 1.1V(also known as DVFS: dynamic voltage frequency scaling), what will be the new dynamic power?

Answer:
First, calculate the reduction due to frequency:

Pnew = 60W×(1.8 / 2.2) ≈ 49.09W

Now, account for voltage scaling:

Pnew = 49.09W × (1.1 / 1.3)^2 ≈ 49.09W × 0.716 = 35.15W

Q10: A processor has a dynamic power consumption of 75W at 2.5 GHz and 1.2V. If a design constraint requires that voltage and frequency be inversely proportional to maintain stability, what is the dynamic power if the voltage is reduced to 1.0V?

Answer:
Determine the new frequency:

f_new = (1.2 / 1.0) × 2.5 GHz = 3.0 GHz

New power:

Pnew = 75W × (3.0 / 2.5) × (1.0 / 1.2)^2 = 75W × 1.2 × 0.6944 ≈ 62.5W