Problem 1

Suppose the time of the four stages of a pipeline are Ʈ1=60ns, Ʈ2=70 ns, Ʈ3=90ns and Ʈ4=80 ns respectively and the interface latch has a delay Ʈ d= 10ns.

Then i) What would be the clock frequency of the above pipeline?

ii) What is the speed up of the pipeline over its equivalent non-pipeline Counterpart?

Solution:

The clock-period should at least t = 90 + 10 = 100 ns. So, the clock frequency, f = 1/t =1/100 = 10 MHz.

In case of non-pipeline, the time delay = t1 + t2 + t3 + t4 = 60 + 70 + 90 + 80 = 300 ns.

So, the speed-up = 300/100 = 3. This means that the pipeline processor is 3 times faster than its equivalent non-pipeline processor.

Problem 2

A program has a parallelizable fraction of 70%. If you have an infinite number of processors available, what is the maximum speedup that can be achieved?

Solution :

Understanding Amdahl's Law

Amdahl's Law describes the theoretical maximum speedup of a program when using multiple processors. It states that the speedup is limited by the sequential (non-parallelizable) portion of the program.

The formula for Amdahl's Law is:

Speedup = 1 / (S + (P / N))

Where:

- **S** is the sequential fraction of the program.
- **P** is the parallelizable fraction of the program.
- **N** is the number of processors.

Applying the Law to the Problem

1. **Identify the given values:**
    - Parallelizable fraction (P) = 70% = 0.70
    - Since the program is either parallelizable or sequential, the sequential fraction (S) is: S = 1 - P = 1 - 0.70 = 0.30
    - Number of processors (N) = infinite (∞)
2. **Apply the formula with infinite processors:**

    - When N approaches infinity, the term (P / N) approaches 0.
    - Therefore, the formula simplifies to: Speedup = 1 / S
3. **Calculate the maximum speedup:**
    - Speedup = 1 / 0.30 = 3.33 (approximately)

Conclusion

With an infinite number of processors, the maximum speedup that can be achieved is approximately 3.33 times.

Problem 3

Suppose a program has a serial portion that takes up 30% of the total execution time. If you parallelize this portion so that it now takes only 20% of the total execution time, calculate the speedup achieved.

Solution:

Initial State: The se0rial portion takes 30% of the total execution time.

Modified State: The serial portion now takes 20% of the total execution time.

We need to find the speedup, which is the ratio of the original execution time to the new execution time.

Calculations

1. **Original Execution Time:**
   - Let's assume the original total execution time is 'T'.

- The serial portion's time is 0.30 * T.
- Therefore, the parallel portion was 1-0.3 = 0.7 or 70% of T.

2. **New Execution Time:**
    - The new serial portion's time is 0.20 * T.
    - The parallel portion time has stayed the same. It is still 0.70 * T.
    - The new total execution time is (0.20 * T) + (0.70 * T) = 0.90 * T.
3. **Calculate Speedup:**
    - Speedup = (Original Execution Time) / (New Execution Time)
    - Speedup = T / (0.90 * T)
    - Speedup = 1 / 0.90
    - Speedup = 1.11 (approximately)

Conclusion

The speedup achieved by reducing the serial portion from 30% to 20% of the total execution time is approximately 1.11 times.