BLG 322E - COMPUTER ARCHITECTURE

Quiz 1

Q-1 SOLUTION:

a)

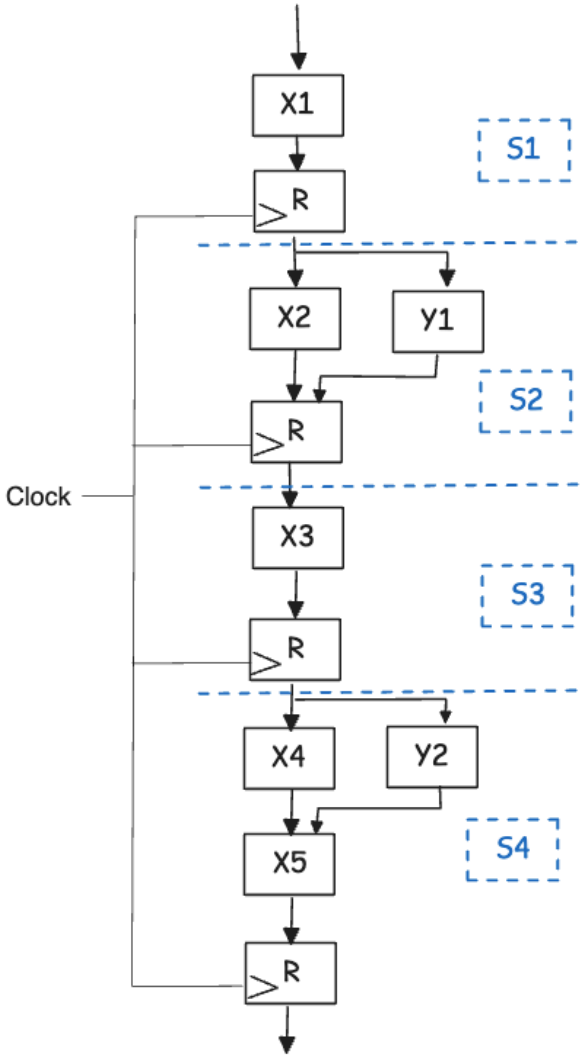

Fig. 1: Pipeline with 4 stages.

We want the highest possible speedup (i.e.\ the smallest pipeline “cycle”) while using the minimum number of registers (each register adds a 5 ns overhead).

- **Stage 1:** X1
  - Logic = 20 ns.
  - With register: 20+5=25 ns.
- **Stage 2:** X2 // Y1
  - Logic = max(15,25)=25 ns.

    - With register: 25+5=30 ns.
- **Stage 3:** X3
    - Logic = 20 ns.
    - With register: 20+5=25 ns.
- **Stage 4:** Must do (X4 // Y2) and then X5.
    - X4 // Y2 = max(20,10)=20, but X5(5 ns) must wait for both to finish.
    - So serially in one stage: 20 + 5 = 25 ns of logic.
    - With register: 25+5=30 ns.

Hence the four stages have lengths of 25, 30, 25, 30 ns.

- The pipeline "cycle time" is the longest = 30 ns.

b) All clock cycles are synced to tp, so the total execution time is

$$T1 = k \,.tp = 4 \,.\, 30 = 120 \text{ ns.}$$

c) Non-Pipelined Time;

1. **X1:** 20 ns
2. **X2** // // **Y1:** max(15,25)=25 ns
3. **X3:** 20 ns
4. **X4** // // **Y2:** max(20,10)=20 ns
5. **X5:** 5 ns

Hence one complete task takes

$$tn = 20 + 25 + 20 + 20 + 5 = 90 \text{ ns.}$$

Infinite-Stream Speedup;

- **Non-Pipelined**: 90 ns per task.
- **Pipelined**: once "filled," it completes one task every 30 ns.

Thus, for an infinite number of tasks,

$$\text{Speedup} = 90 / 30 = 3.$$

Q-2 SOLUTION:

a) The total clock cycles = (number of A x CPI_A) + (number of B s CPI_B) + (number of C x CPI_C).

For S1:

Cycles S1=3×1 + 2×2 + 1×5=3+4+4=11 cycles.

For S2:

Cycles S2=2×1 + 3×2 + 2×4=2+6+8=16 cycles.

Hence, S1 is faster overall, even though S2 uses only one more instruction. The reason is that S2 has more B and C instructions, which have higher CPI values, driving up its total cycle count.

b) The effective CPI = (total clock cycles) / (total instruction count).

S1:

Effective CPI_{S1}=11 cycles / 6 instructions ≈ 1.83.

S2:

Effective CPIS2=16 cycles/ 7 instructions ≈ 2.29.

Thus S1 not only finishes in fewer cycles but also has the lower effective CPI (≈1.83 vs.\ 2.29).