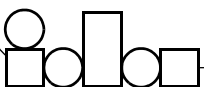


# **Seminar 2**

**1. Instruction Pipelining**

**2. Superscalars**

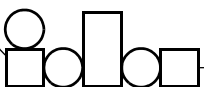
**3. Parallel Architectures**



## Problem 1

A nonpipelined processor has a clock rate of 2.5 GHz. An upgrade to the processor introduces a five-stage pipeline. However, due to internal pipeline delays, the clock rate of the new processor has to be reduced to 2 GHz.

What is the speedup achieved for a sequence of 100 instructions?

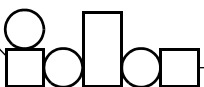


## Problem 2

Consider the following assembly language program:

I1:	Move R3, R7	$R3 \leftarrow R7$
I2:	Load R8, (R3)	$R8 \leftarrow (R3)$
I3:	Add R3, R3, 4	$R3 \leftarrow R3 + 4$
I4:	Load R9, (R3)	$R9 \leftarrow (R3)$
I5:	BLE R8, R9, L3	Branch if $R9 > R8$

Show the dependencies.



### Problem 3

a. Identify the dependencies in the following code:

I1:  $R1 \leftarrow R6 + 100$

I2:  $R5 \leftarrow R1 + R2$

I3:  $R7 \leftarrow R5 + 1$

I4:  $R1 \leftarrow R2 + R4$

I5:  $R5 \leftarrow R6 + 22$

I6:  $R2 \leftarrow R4 - 25$

I7:  $R3 \leftarrow R7 - 2$

I8:  $R4 \leftarrow R1 + R3$

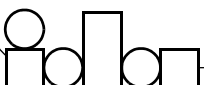
I9:  $R10 \leftarrow R6 - 100$

I10:  $R1 \leftarrow R1 + 30$

b. Rename the registers in the above sequence to prevent, where possible, dependency problems.

c. Consider a superscalar computer on which the execution of each instruction takes one cycle; the computer has two arithmetic units. Show how instructions are executed in consecutive cycles with:

- c1) in order execution;
- c2) out of order execution before renaming;
- c3) out of order execution after renaming.



## Problem 4

An application program is executed on a nine-processor cluster. The program took time  $T$  on this cluster. Further, it was found that 25% of  $T$  was time in which the application was running simultaneously on all nine processors. The remaining time, the application had to run on a single processor.

- a. Calculate the speedup under the aforementioned conditions (relative to execution on a single processor).
- b. Suppose that we are able to effectively use 17 processors rather than 9 on the parallelized portion of the code. Calculate the speedup (relative to execution on a single processor) that is achieved.

