

Advanced Computer Architecture

Tutorial 1

Instruction Pipeline & Performance



NPTEL Online Course : Advanced Computer Architecture : Dr. John Jose, IIT Guwahati

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Instruction Encoding

Consider the case of a processor with 32 general purpose registers and an instruction length of 16-bits. The processor has a main memory (RAM) addressability of 256Bytes. It has 32 Type -I instructions each with two register operands, two Type-II instructions each with a register and a memory operand, and N type III instruction each with one register operand. What is the maximum possible value of N? Show an instruction encoding format and its interpretation.

16 bit Instruction

I	0	XXXXX (5 bits) (32 COMBINATIONS)	5 Bit Reg name	5 Bit Reg name
II	1	00 /01 (2)	5 Bit Reg name	8 Bit Memory Address
III	1	10 11	XXXXXXXXX (8 bits) (512 COMBINATIONS)	5 Bit Reg name

Amdahl's Law

A new floating-point unit speeds up floating point operations by two times. In an application one fifth of the instructions are floating-point operations.

(a) What is the overall speedup? (Ignore the penalty to other instructions).

(b) Assume that the speeding up of the floating-point unit mentioned above slowed down data cache accesses resulting in a 1.5x slowdown. Assume the load instructions constitute 15% and store instructions constitute 9% of the total instruction what is the effective overall speedup now?

(c) $S = 1 / \{ (1-f) + (f/N) \} = 1 / \{ (1- 0.2) + (0.2/2) \} = 1.11 \text{ times}$

(d) $S = 1 / \{ (1-f_1-f_2) + (f_1/N_1) + (f_2/N_2) \}$
 $= 1 / \{ (1- 0.2-0.24) + (0.2/2) + (0.24/0.67) \} = 0.98 \text{ times}$

Amdahl's Law

Suppose a processor spends 75% of its time in memory operations (both I-cache and D-cache access together) when running a given program A and its manufacturers make a change that improves its performance on memory access by a factor of 5. The program A originally took 100s to execute.

What is the speed up from the old system to the new system? What fraction of its execution time does the new system spend in memory operations?

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(a) $S = 1 / \{(1-f) + (f/N)\} = 1 / \{(1 - 0.75) + (0.75/5)\} = 2.5 \text{ times}$

$$S = \text{ExT old} / \text{ExT new} \rightarrow 2.5 = 100 / \text{ExT new} \quad \text{ExT new} = 40 \text{ s}$$

(b) Out of 100 s in old system 75% is memory $\rightarrow 75 \text{ s}$.

This 75 s got speeded up by factor of 5 $\rightarrow 75/5 = 15 \text{ s}$

Hence, fraction of memory in new is $15/40 = 37.5\%$

Pipeline Design

- ❖ The time delay of a 4-segment pipeline in different segments are $t_1=35$ ns, $t_2 = 30$ ns, $t_3 = 40$ ns, $t_4=45$ ns. The interface register delay time is $t=5$ ns. How long would it take to complete 100 instructions in the pipeline ? (Assume there is no dependency between the instructions).

**THANK
YOU!**

FOR

YOUR

PRESENCE

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