# ACOL216: Tutorial 7

## Date: March 30, 2026

1. A machine has a 32-bit architecture, with 1-word long instructions. It has 64 registers, each of which is 32 bits long. It needs to support 45 instructions, which have an immediate operand in addition to two register operands. Assuming that the immediate operand is an signed two's complement integer, the range of the immediate operand is?

2. A processor has 128 registers and uses 32-bit instruction format. It has two types of instructions: I-type and R-type. Each I-type instruction contains an opcode, a register name, and a 8-bit immediate value. Each R-type instruction contains an opcode and two register names. If there are 32 distinct I-type opcodes, then the maximum number of distinct Rtype opcodes is:

3. A processor has 16 integer registers (R0, R1, …., R15) and 64 floating point registers (F0, F1, …., F63). It uses a 2-byte instruction format. There are four categories of instructions: Type-1, Type-2, Type-3 and Type-4. Type-1 category consists of four instructions, each with 3 integer register operands (3Rs). Type-2 category consists of eight instructions, each with 2 floating point register operands (2Fs). Type-3 category consists of fourteen instructions, each with one integer register operand and one floating point register operand (1R+1F). Type-4 category consists of N instructions, each with a floating-point register operand (1F). The maximum value of N is:

4. Consider a Processor with 128 registers and an instruction set of size fourteen. Each instruction has five distinct fields, namely, opcode, two source register identifiers, one destination register identifier, and a twelve-bit immediate value. Each instruction must be stored in memory in a bytealigned fashion. If a program has 100 instructions, the amount of memory (in bytes) consumed by the program text is:

(1) Ans = $0 - 2^{13}$ to $2^{13} - 1$ ✓

↳ 32-bit Machine

↳ 1 word = 32-bit

Instruction Size = 1-word

= 32-bit

45 operations = Opcode

= bits for Opcode = 6-bit

64 Registers = 6-bit

Instruction format

| Opcode | Reg1 | Reg2 | Immidiate operand |
|---|---|---|---|
| 6-bit | 6-bit | 6-bits | x-bit |

⇒ $6 + 6 + 6 + x = 32$

⇒ $x = 32 - 18 = 14$

n-bit Signed 2's comp.

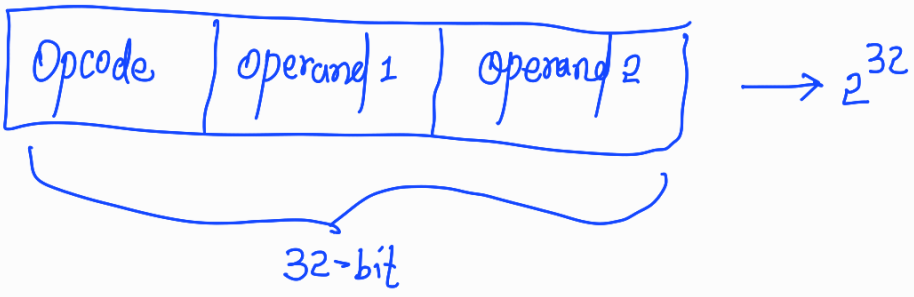
$-2^{n-1}$ to $2^{n-1} - 1$

$-2^{13}$ to $2^{13} - 1$

(2) Ans :- $2^{17} - 32$ = R-type

Instruction is of 32-bit

$\rightarrow 2^{32}$




$\rightarrow 2^{32}$

128 Registers $\longrightarrow$ 7-bits

Immidiate Value $\longrightarrow$ 8-bits

I-type = 32 distinct instruct

$\rightarrow$ 32 distinct opcode.

Total possible I-type = $32 \times 2^7 \times 2^8 = 2^5 \times 2^7 \times 2^8$

+

Total possible R-type = $x \times 2^7 \times 2^7$

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Total possible instruction encodings = $2^{32}$

$\Rightarrow 2^{20} + x \times 2^{14} = 2^{32}$

$\Rightarrow 2^{14}\left[2^6 + x\right] = 2^{32}$

$\Rightarrow x = 2^{18} - 2^6$

(3) We have 2-bytes of instruction size/format

$\rightarrow 2^{16}$

Types 1 = 4 inst. with 3 IR Operands $= 4 \times 2^4 \times 2^4 \times 2^4$

+

Type 2 = 8 inst with 2 FR operands $= 8 \times 2^6 \times 2^6$

+

Type 3 = 14 inst. with 1 IR and 1 FR operands $= 14 \times 2^4 \times 2^6$

+

Type 4 = N inst. 1 FR $= N \times 2^6$

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$2^{16}$

16 IR $\rightarrow$ 4-bits

64 FR $\rightarrow$ 6-bits

$\Rightarrow 4 \times 2^{12} + 8 \times 2^{12} + 14 \times 2^{10} + N \times 2^6 = 2^{16}$

$\Rightarrow N = \left\{ 2^{16} - \left[ 4 \times 2^{12} + 8 \times 2^{12} + 14 \times 2^{10} \right] \right\} / 2^6$

(4) 128 registers = 7-bit

14 instructions in a instructions set $\rightarrow$ 4-bit

| Opcode | SR1 | SR2 | DR | Immidiate |
|---|---|---|---|---|
| 4 | 7 | 7 | 7 | 12 |

$4 + 7 + 7 + 7 + 12 = 37$-bit

$= 5$ Bytes

If it has 100 such instruction set,

Total in $100 \times 5 = 500$ byte