UCCD1133

Introduction to Computer Organisation and Architecture

Chapter 4-3

Addressing Modes

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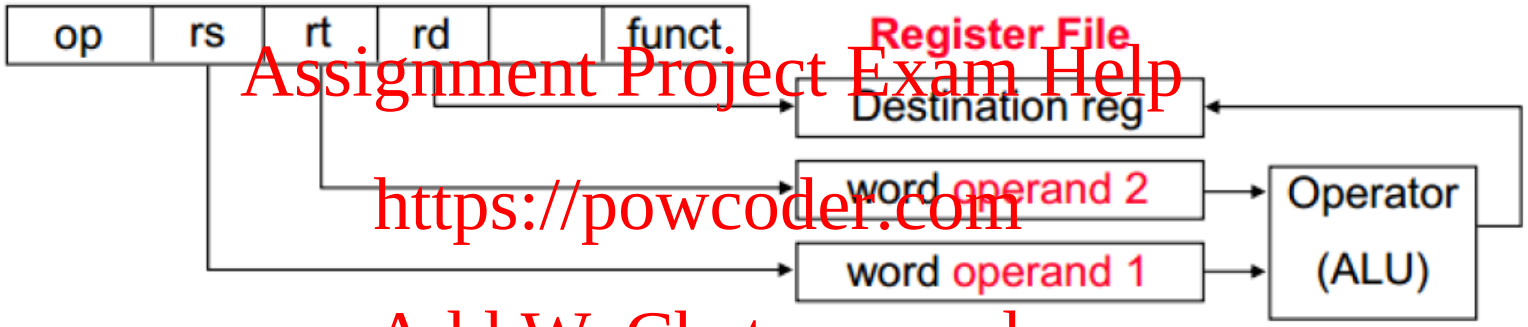
Addressing Modes

- What is addressing mode?
  - Addressing modes are the ways of specifying an operand or a memory address.
  - The address of the operand determined is called the effective address.

- Basic MIPS addressing modes:
  - Register addressing
  - Immediate addressing
  - Base (displacement) addressing
  - PC-Relative addressing
  - Pseudo-direct addressing

Register addressing

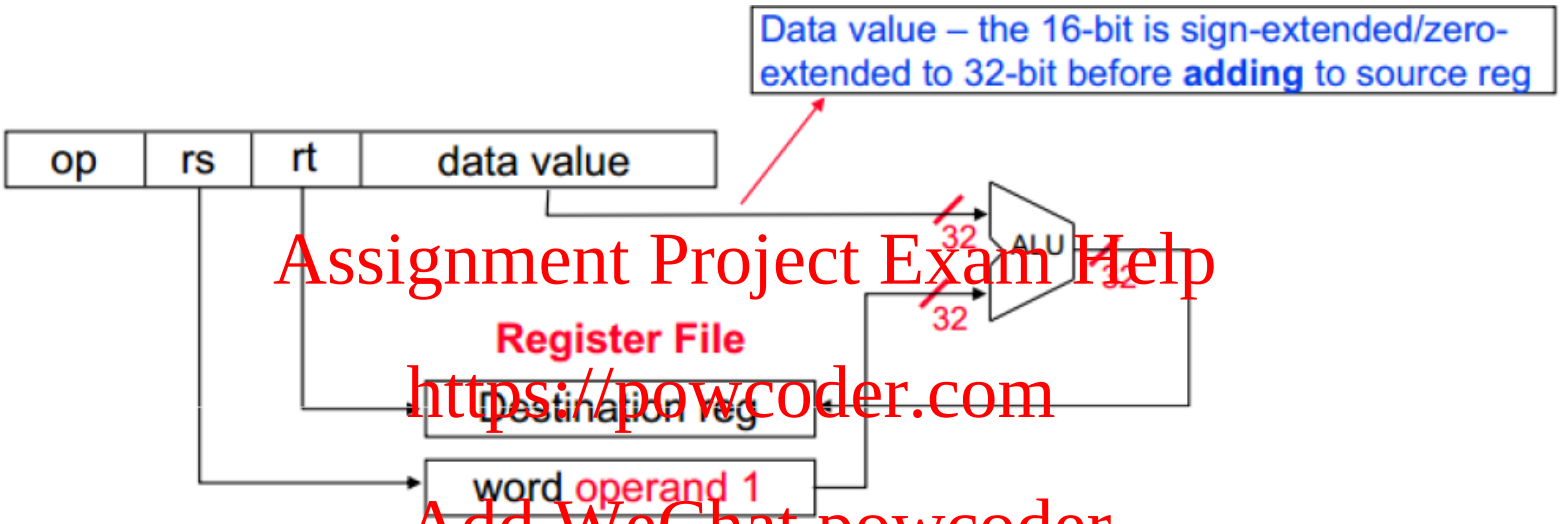
- The operand is in a register.
  - Example: `add $s0, $t2, $t3`
  - Example: `sub $t8, $s1, $0`



- Used by instructions:
  - Arithmetic instructions: add, sub, …
  - Logical instructions: and, or, sll, srl, …
  - Program control instructions: slt, sltu, jr, …

Immediate Addressing

- The operand is a 16-bit constant contained within the instruction.
  - Example: `ori  $t3, $t7, 0x00FF`

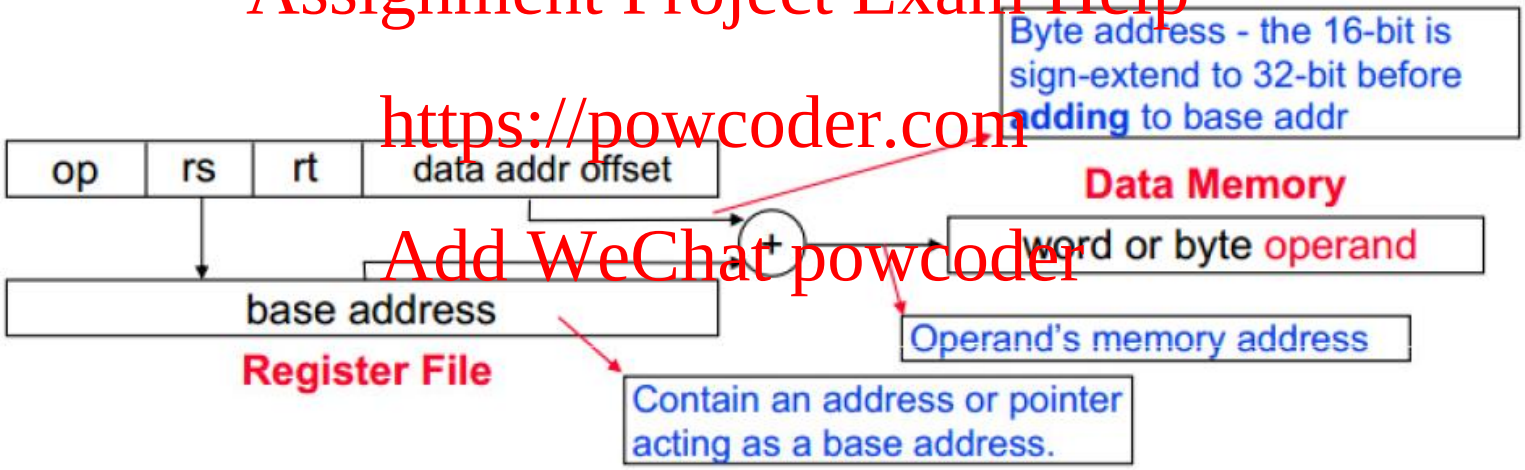


- Used by instructions:
  - Arithmetic and logical instructions: addi, andi, ori, …
  - Data transfer instructions: lui
  - Program control instructions: slti, sltiu, …

- Zero-extending 16-bit – logical immediate instructions (andi, ori, etc.)
- Sign-extending 16 bit – arithmetic and program control immediate instructions (addi, addiu, slti, sltiu, etc)

Base (displacement) addressing

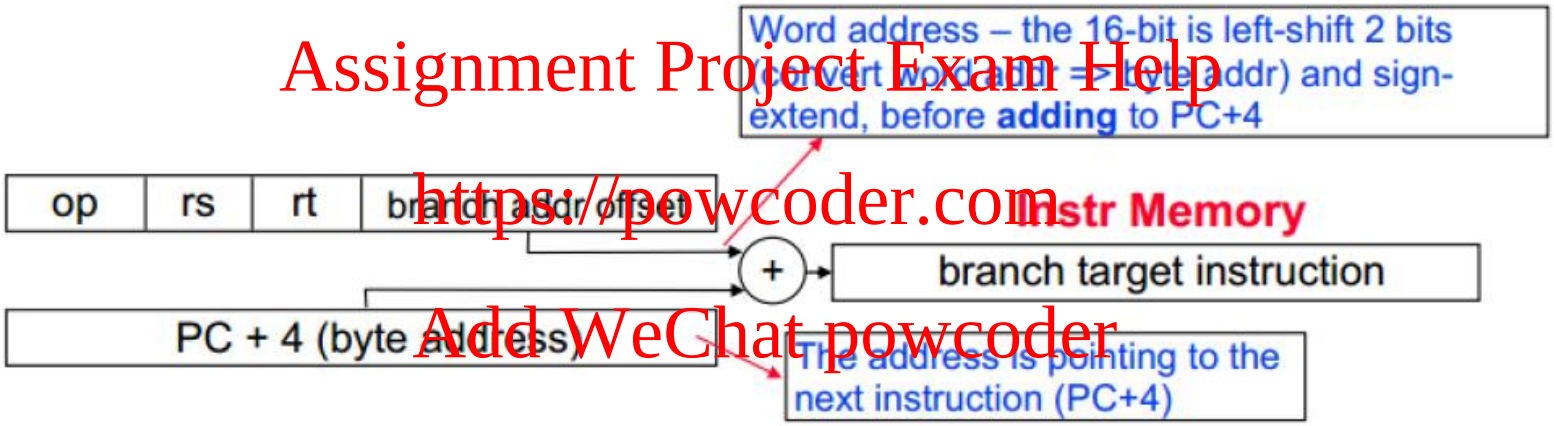
- The operand's memory address = `base address + sign-extended immediate`
  - Example: `lw  $s4, 72($0)`
  - address = `$0 + 72`
  - Example: `sw  $t2, -24($t1)`
  - address = `$t1 - 24`



- Used by instructions:
  - Data transfer instructions: lw, sw, lb, sb, …

PC-Relative Addressing

- The new instruction's memory address is obtained by summing the PC and a 16-bit constant contained within the current instruction.
- Used by instructions:
  - Branch instructions: beq, bne



PC-Relative Addressing

- The new instruction's memory address is obtained by summing the PC and a 16-bit constant contained within the current instruction.

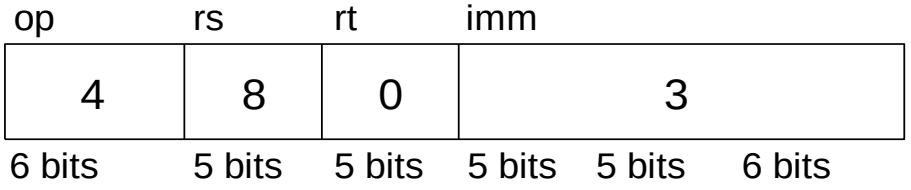
  - Example:

```
0x10            beq   $t0, $0, else
0x14            addi  $v0, $0, 1
0x18            addi  $sp, $sp, i
0x1C            jr    $ra
0x20      else: addi  $a0, $a0, -1
0x24            jal   factorial
```


Assembly Code

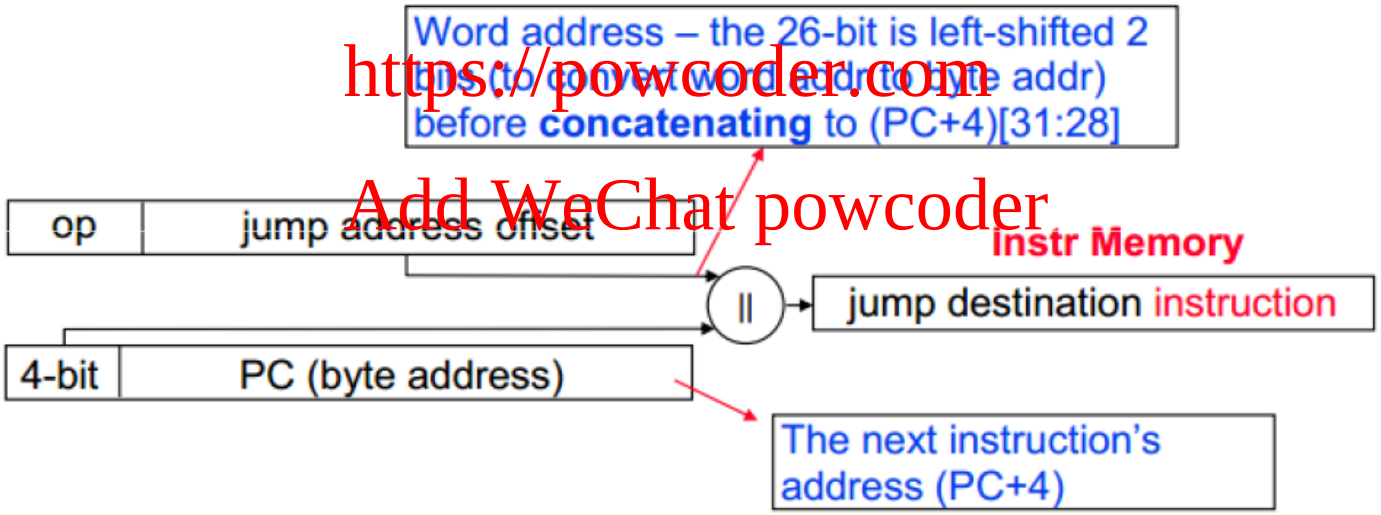
```
beq $t0, $0, else
(beq $t0, $0, 3)
```

Field Values



Pseudo-direct Addressing

- The new instruction's address (jump target address) in memory is obtained by concatenating the left-shifted 26-bit constant contained within the current instruction with the upper 4-bits of the PC.
- Used by instructions:
  - Jump instructions: j, jal.



Pseudo-direct Addressing

- The new instruction's address (jump target address) in memory is obtained by concatenating the left-shifted 26-bit constant contained within the current instruction with the upper 4-bits of the PC.

  - Example:

```
0x0040005C          jal   sum
...
0x004000A0  sum:    add   $v0, $a0, $a1
```


JTA 0000 0000 0100 0000 0000 0000 1010 0000 (0x004000A0)

26-bit addr 0000 0000 0100 0000 0000 0000 1010 0000 (0x0100028)

0 1 0 0 0 2 8

Field Values

op	imm
3	0x0100028
6 bits	26 bits

Machine Code

op	addr	
000011	00 0001 0000 0000 0000 0010 1000	(0x0C100028)
6 bits	26 bits	

MIPS Memory Map

- What is stored in memory?
  - Instructions (also called text)
  - Data
    - Global/static: allocated before program begins
    - Dynamic: allocated within program
- How big is memory?
  - At most 232 = 4 gigabytes (4 GB)
  - From address 0x00000000 to 0xFFFFFFFF