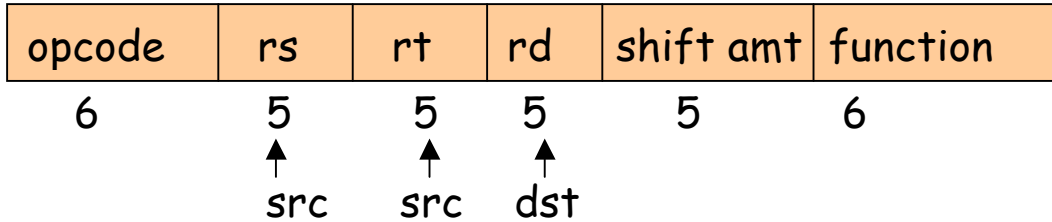


## MIPS registers

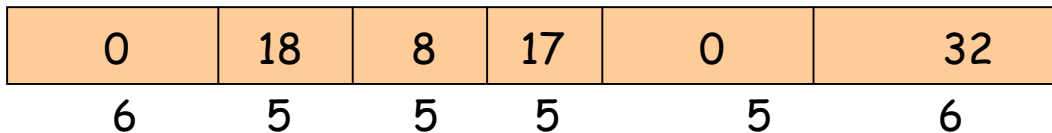
register	assembly name	Comment
r0	\$zero	Always 0
r1	\$at	Reserved for assembler
r2-r3	\$v0-\$v1	Stores results
r4-r7	\$a0-\$a3	Stores arguments
r8-r15	\$t0-\$t7	Temporaries, not saved
r16-r23	\$s0-\$s7	Contents saved for later use
r24-r25	\$t8-\$t9	More temporaries, not saved
r26-r27	\$k0-\$k1	Reserved by operating system
r28	\$gp	Global pointer
r29	\$sp	Stack pointer
r30	\$fp	Frame pointer
r31	\$ra	Return address

## MIPS instruction formats

Instruction "add" belongs to the **R-type format**.



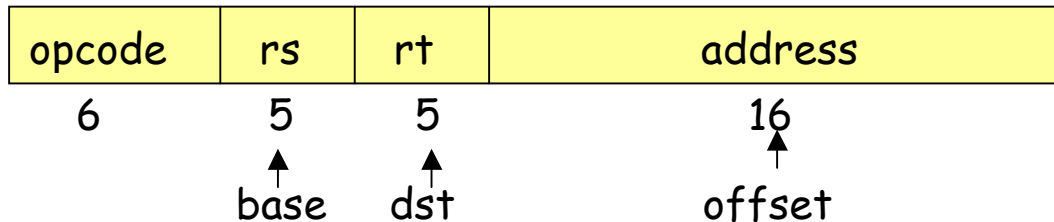
add \$s1, \$s2, \$t0      will be coded as



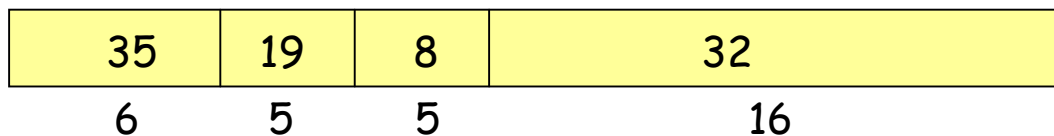
The "function" field is an extension of the opcode, and they together determine the operation.

Note that "sub" has a similar format.

Instruction "lw" (load word) belongs to **I-type format**.



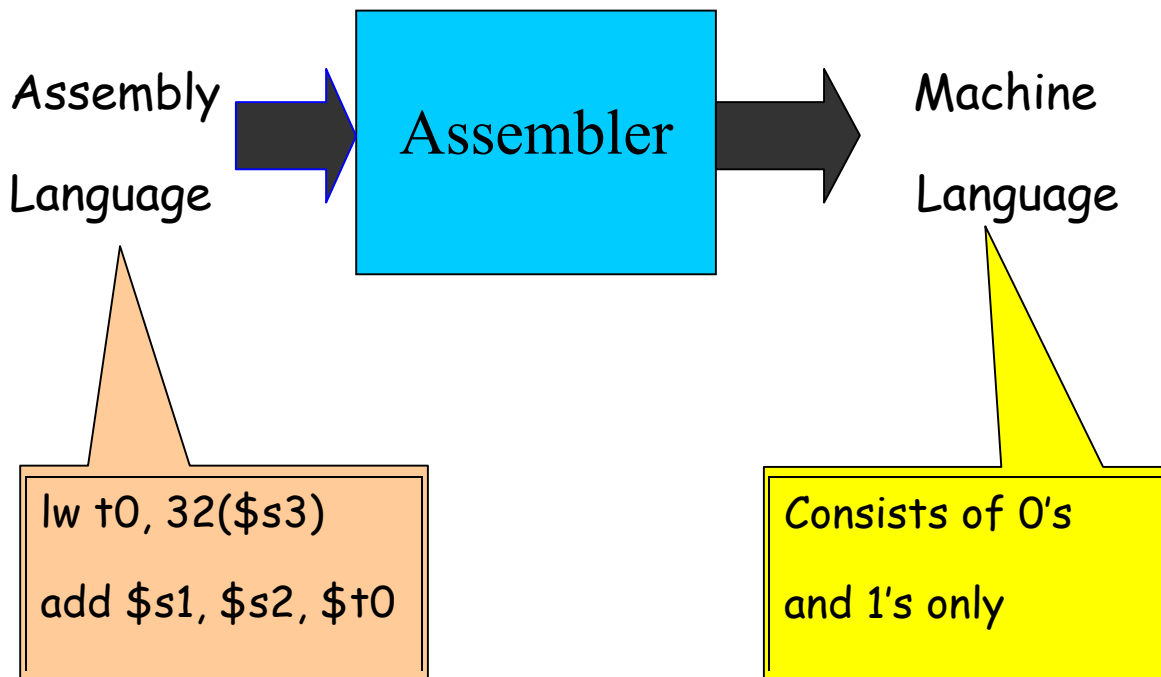
lw \$t0, 32(\$s3)      will be coded as



Both "lw" and "sw" (store word) belong to I-format.

MIPS has (fortunately) only three different instruction formats. The operation codes determine the format. This is how the control unit interprets the instructions.

# What is an Assembler?



If you know the instruction formats, then you can translate it. The machine language consists of 0's and 1's

## Pseudo-instructions

These are simple assembly language instructions that do not have a direct machine language equivalent. During assembly, the **assembler** translates each **pseudo-instruction** into one or more machine language instructions.

### Example

**move \$t0, \$t1**    # \$t0 ← \$t1

The **assembler** will translate it to

**add \$t0, \$zero, \$t1**

We will see more of these soon.

## Think about these

Q1. How will you load a constant into a memory location (i.e. consider implementing  $x := 3$ )?

(Need some immediate mode instructions, like `li` which is a **pseudo-instruction**)

Q2. How will you implement  $x := x + 1$  in assembly language?

What do you think?

Q3. Why is the load (and store too) instruction so "crooked?"

Used for its flexibility, let us discuss it.

Q4. How will you load a constant (say 5) into a register?

(Need the immediate mode instructions, like `addi`)

## Loading a 32-bit constant into a register

The pseudo-instruction "load immediate"

```
li $s0, 0x003A0012
```



hexadecimal

means "load the 32-bit constant into register \$s0."

Internally it is translated into

```
lui $s0, 42      # load upper-half immediate
```

```
ori $s0, $s0, 18 # (one can also use andi)
```

# Logical Operations

Shift left (logical)                      sll

Shift right (logical)                    srl

Bit-by-bit AND                            and, andi (and immediate)

opcode	rs	rt	rd	shift amt	function
6	5	5	5	5	6
	↑	↑	↑		
	src	src	dst		

sll \$t2, \$s0, 4 means \$t2 = \$s0 << 4 bit position

(s0 = \$16, t2 = \$10)

0	0	16	10	4	0
6	5	5	5	5	6

s0 = 0000 0000 0000 0000 0000 0000 0000 1001

t2 = 0000 0000 0000 0000 0000 0000 1001 0000

Why are these instructions useful?