

- ① Description of a machine
(user's view, programmer's view, compiler writer)
- ② Behavior (functionality) of a machine
- ③ Hardware view of a machine

① Definition or description of a machine is given by the instruction set report.

- instruction set
- along with the register structure and the memory structure

for instruction set

- syntax
- semantics

eg: MIPS → registers 32 (\$0, \$1, \$2, ..., \$31)
 visible registers (aka the programmer can refer to)
 → Hi, Lo (invisible registers) are used to hold the result of multiplication. Can only be used indirectly (mfhi and mflo)
 → Each register is 32 bits long

Data Memory (DM)

Program Counter (PC)

MIPS: 2^{30} words

② or \$2, \$1, \$5

$\$2 \leftarrow \$1 \mid \$5$

$\$2[i] \leftarrow \$1[i] \mid \$5[i]$

example:

\$1 =	1	0	1	0	1	0
\$5 =	1	1	0	0	1	1
$\therefore \$2 \leftarrow$	1	1	1	0	1	1

③ lw \$4, \$3, 25 — offset
 lw \$4, 25(\$3)

destination sources

$\$4 \leftarrow DM[\$3 + 25]$

④ sw \$4, \$3, 25 — ~~offset~~ offset
 sw \$4, 25(\$3)

source destination

$DM[\$3 + 25] \leftarrow \4

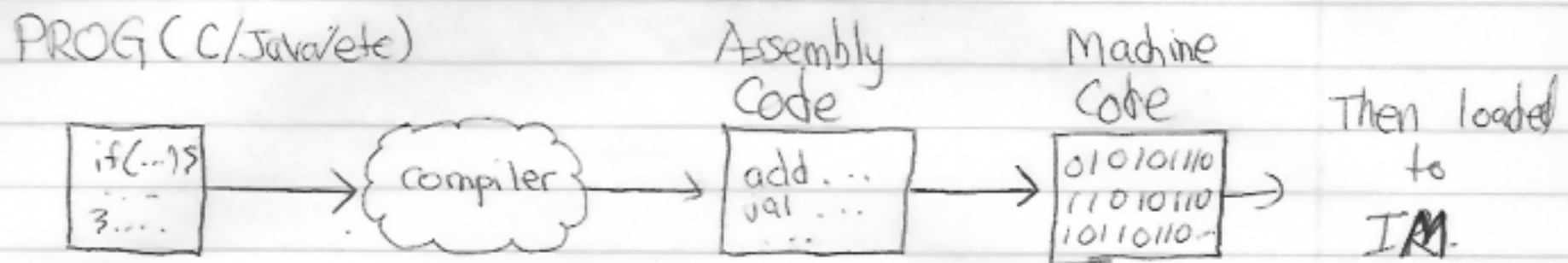
⑤ beq \$2, \$4, 20

If ($\$2 = \4) Then
 $PC \leftarrow PC + 4 + (4 * 20)$
↑ offset
 branch target addr

⑥ j 450

$PC \leftarrow 450$

② Behavior (functionality) of a machine is given as an algorithm - called Instruction Processing Cycle (IPC).



Generic Version of IPC (without specifics of a particular machine)

REPEAT

1. Instruction Fetch
2. Increment Program Counter
3. Decode Op Code
4. Calculate the addresses of operands
5. Operand Fetch
6. Execute Instruction

GOTO REPEAT

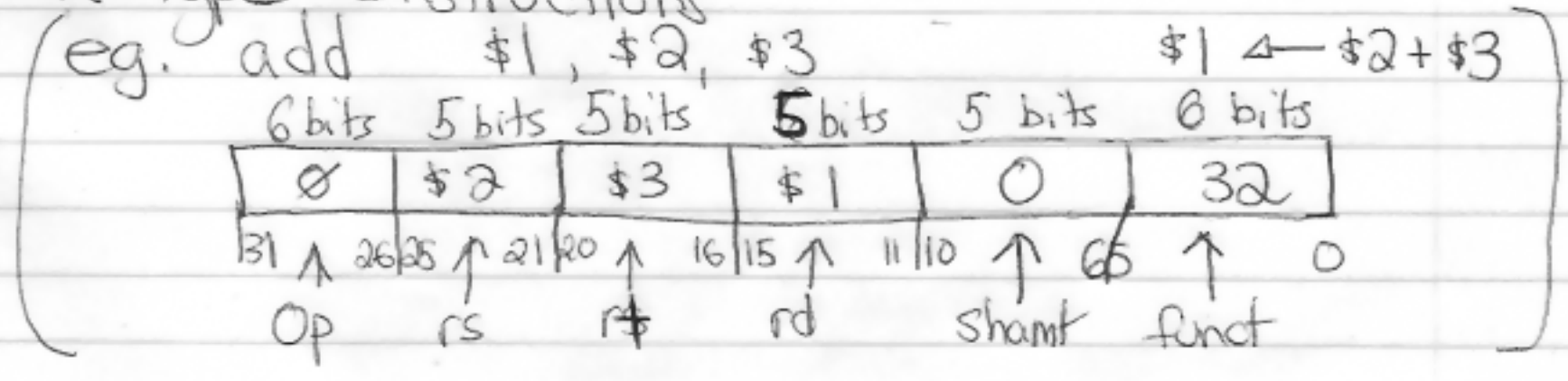
- Here,
- Variables in the IPC become registers and arrays
 - Functions in the IPC become varieties of functional units
- Hardware

MIPS Machine Language formats (See Handout)

- Instruction Word = 32 Bits



- R-type Instructions



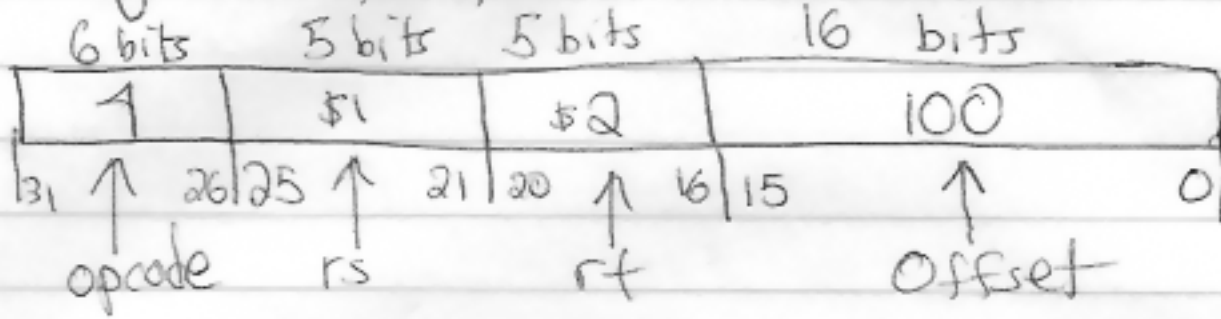
For R-Type, op-field is always 0 (funct field determines the operation)

rd stands for destination

rs, rt are sources

• I-Type Instructions

eg. beq \$1, \$2, 100 if (\$1 == \$2) PC ← PC + 4 + 4 * 100

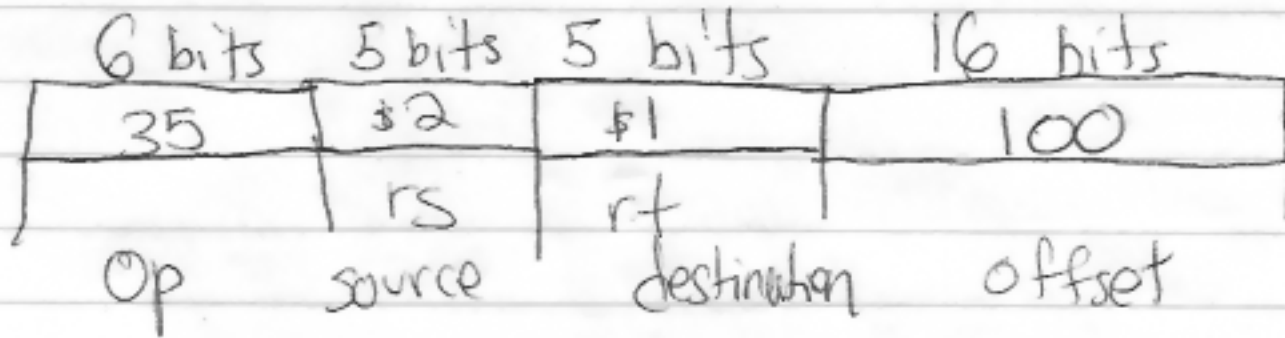


for beq opcode = 4

eg. opfield = 5 if ~~the~~ bne

eg. LW \$1, \$2, 100

$\$1 \leftarrow \text{DM}[\$2 + 100]$



eg. sw Op = 43

• J type

Op = 2

IR[26...31] = 2
OPR = IR[3...25]

Flow of Control Signals In MIPS

