COMP 303
Computer Architecture
Lecture 4

Load Upper Immediate

- Example: lui R8, 255

31 – 26	25 – 21	20 – 16	15 – 0
001111	**00000**	**01000**	**0000 0000 1111 1111**
op	rs	rt	immediate

- Transfers the immediate field into the register's top 16 bits and fills the register's lower 16 bits with zeros

  R8[31:16] <-- 255

  R8[15:0] <-- 0

	31 – 16	15 – 0
R8	**0000 0000 1111 1111**	**0000 0000 0000 0000**

Large constants

- We'd like to be able to load a 32 bit constant into a register
- Must use two instructions, new "load upper immediate" instruction

```
lui $t0, 1010101010101010
```

filled with zero

31 — 16	15 — 0
1010 1010 1010 1010	**0000 0000 0000 0000**

- Then must get the lower order bits right, i.e.,

```
ori $t0, $t0, 1111000011001010
```

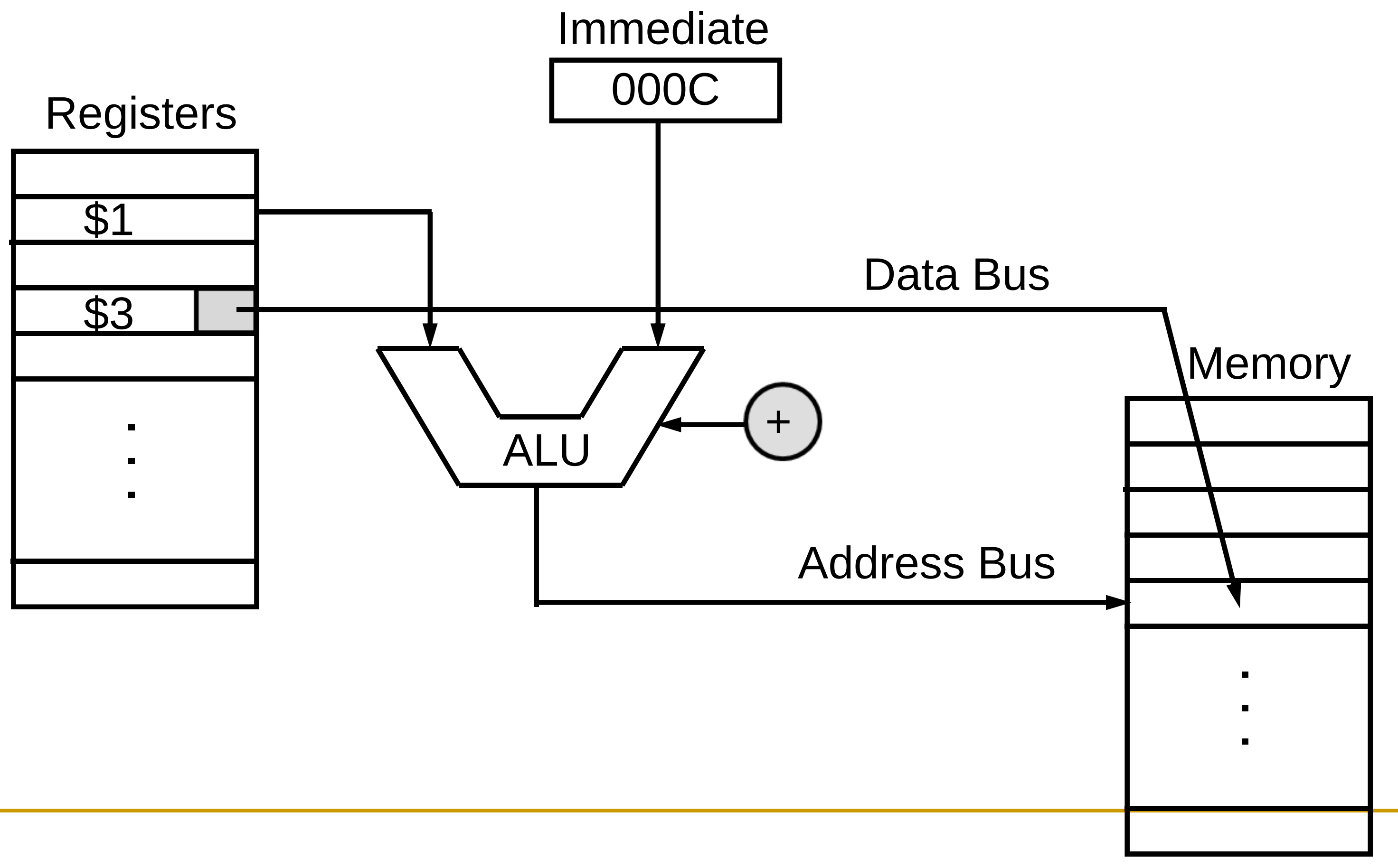
	1010 1010 1010 1010	**0000 0000 0000 0000**
ori	**0000 0000 0000 0000**	**1111 0000 1100 1010**
	1010 1010 1010 1010	**1111 0000 1100 1010**

MIPS data transfer instructions

Instruction	*Comment*
sw $3, 500($4)	Store word
sh $3, 502($2)	Store half
sb $2, 41($3)	Store byte
lw $1, 30($2)	Load word
lh $1, 40($3)	Load halfword
lhu $1, 40($3)	Load halfword unsigned
lb $1, 40($3)	Load byte
lbu $1, 40($3)	Load byte unsigned
lui $1, 40	Load Upper Immediate (16 bits shifted left by 16)

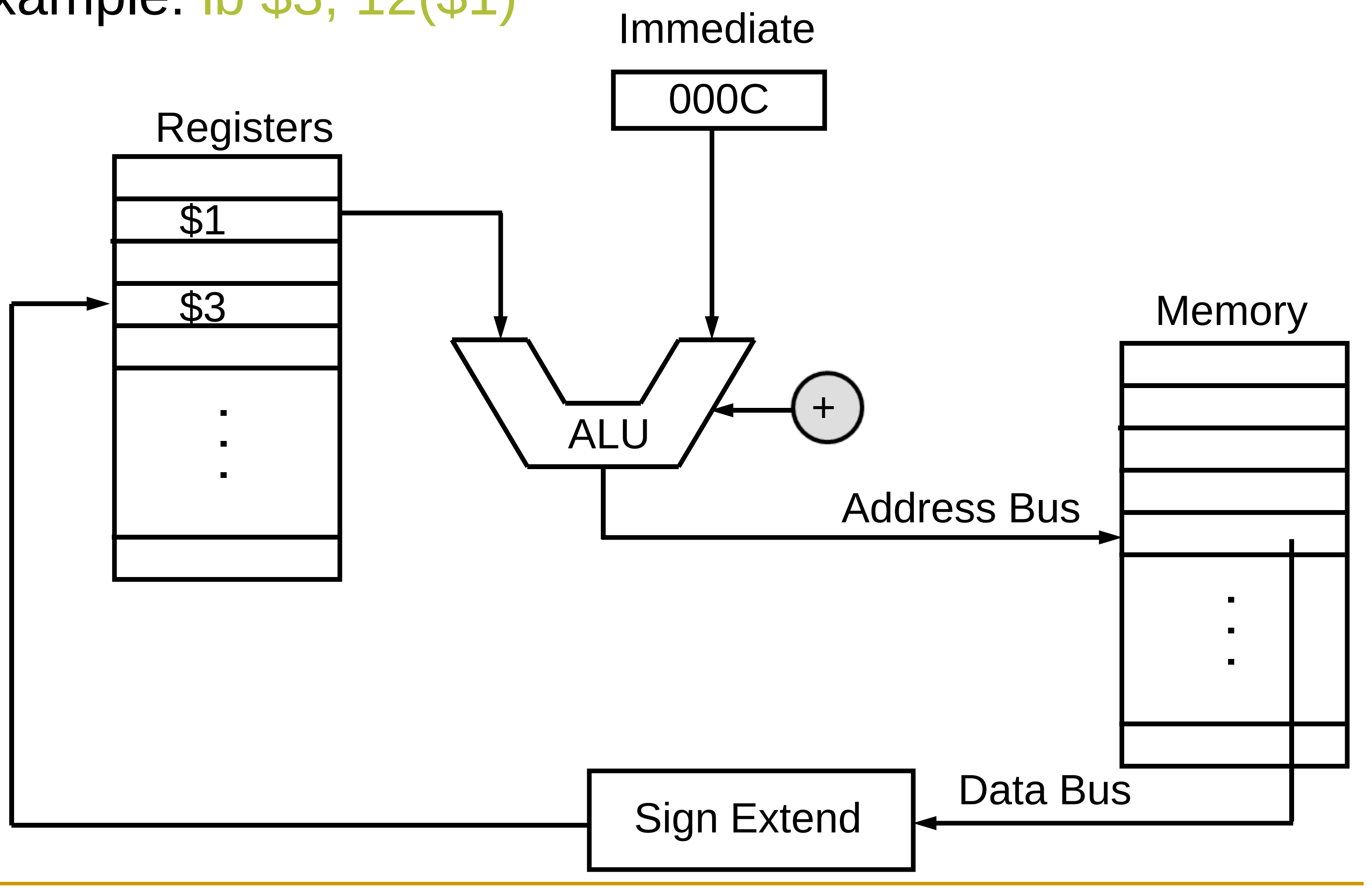
Store byte (sb) instruction

- Example: sb $3, 12($1)

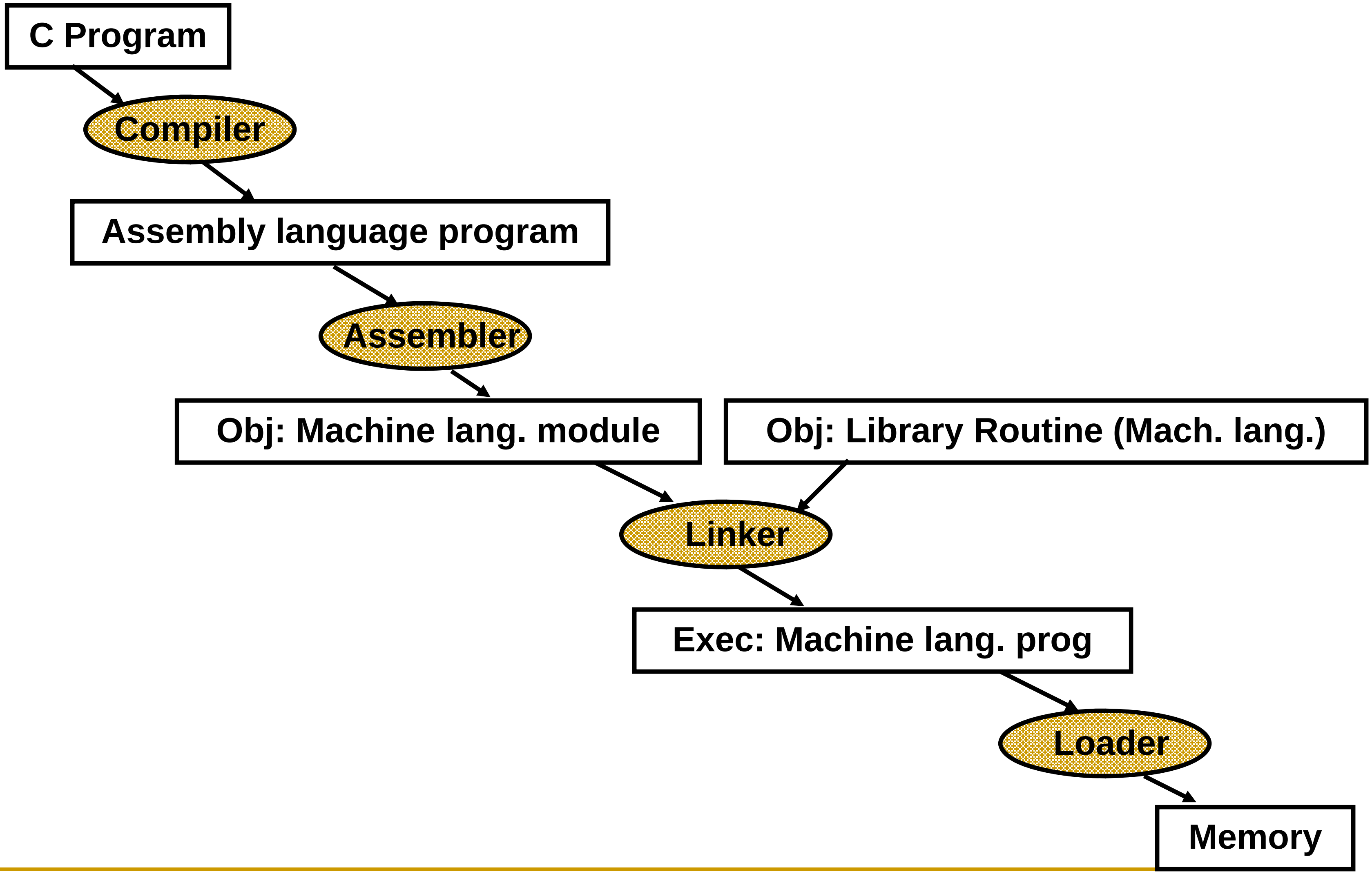


Load byte (lb) instruction

- Example: lb $3, 12($1)



Translating and starting a program



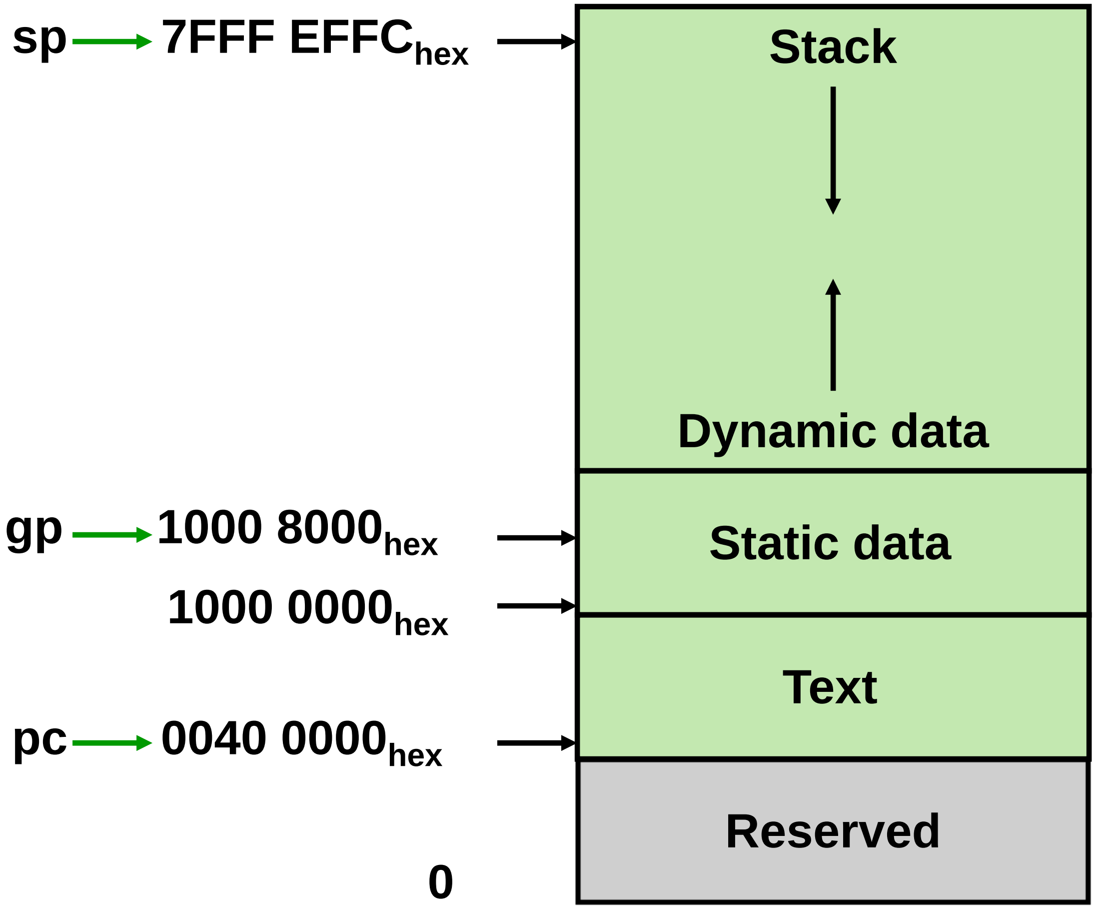
Assembly language

- **Assembly language** is the symbolic representation of a computer's binary encoding, which is called **machine language.**
- Assembly language is more readable than machine language because it uses symbols instead of bits.
- Assembly language permits programmers to use ***labels*** to identify and name particular memory words that hold instructions or data.
- A tool called ***assembler*** translates assembly language into binary instructions.
- An assembler reads a single assembly language *source file* and produces *object file* containing machine instructions and bookkeeping information that helps combine several object files into a program.

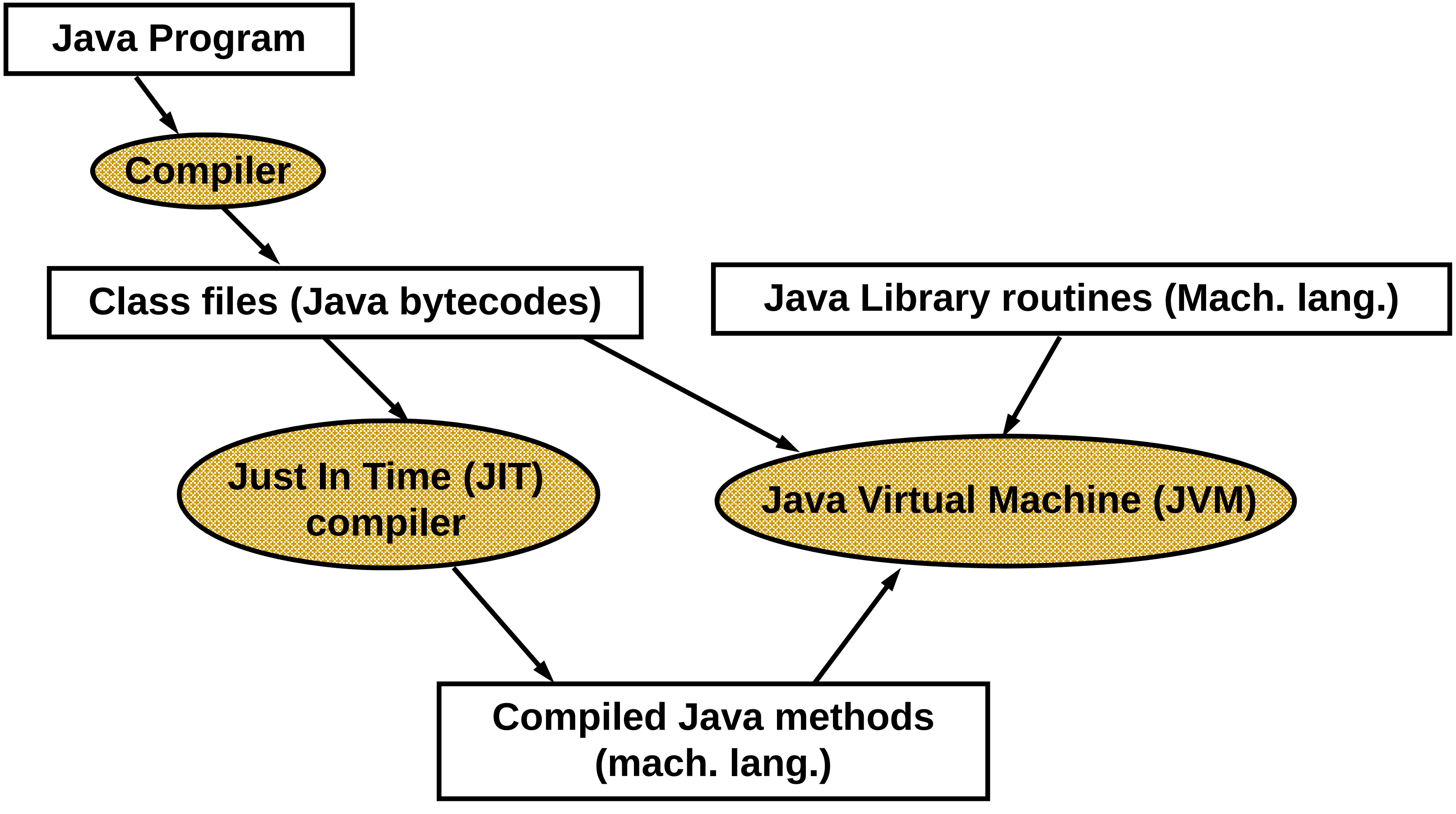
Advantages & disadvantages

- Assembly programming is useful when the speed or size of a program is important.
- But assembly languages are machine specific and they must be rewritten to run on another machine.
- Another disadvantage is that assembly language programs are longer than the equivalent programs written in a high-level languages.
- It is also true that programs written in assembly are more difficult read and understand and they may contain more bugs.

MIPS memory allocation for program & data



A translation hierarch for Java



Array vs pointer

```
void clear1(int array[ ], int size)
{
    int i;
    for (i = 0;  i < size;  i++);
            array[i] = 0;
}
```

```
void clear2(int *array, int size)
{
    int *p;
    for (p = &array[0];  p< &array[size];  p++);
            *p = 0;
}
```

Array version of "clear"

- Assume that the two parameters `array` and `size` are found in the registers `$a0` and `$a1`, and that `i` is allocated to register `$t0`.

```
        move $t0,$zero          # i = 0
loop1:  add  $t1,$t0,$t0        # $t1 = i * 2
        add  $t1,$t1,$t1        # $t1 = i * 4
        add  $t2,$a0,$t1        # $t2 = address of array[i]
        sw   $zero,0($t2)       # array[i] = 0
        addi $t0,$t0,1          # i = i + 1
        slt  $t3,$t0,$a1        # $t3 = (i < size)
        bne  $t3,$zero,loop1    # if (i < size) go to loop1
```

Pointer version of "clear"

- Assume that the two parameters `array` and `size` are found in the registers `$a0` and `$a1`, and that p is allocated to register `$t0`.

```
        move   $t0,$a0            # p = address of array[0]
        add    $t1,$a1,$a1        # $t1 = size * 2
        add    $t1,$t1,$t1        # $t1 = size * 4
        add    $t2,$a0, $t1       # $t2=address of array[size]
loop2:  sw     $zero,0($t0)       # Memory[p] = 0
        addi   $t0,$t0,4          # p = p + 4
        slt    $t3,$t0,$t2        # $t3 = (p < &array[size])
        bne    $t3,$zero,loop2    # if (p < &array[size]) go
                                  # to loop2
```

Comparing two versions of “clear”

```
        move    $t0,$zero              # i = 0
loop1:  add     $t1,$t0,$t0            # $t1 = i * 2
        add     $t1,$t1,$t1            # $t1 = i * 4
        add     $t2,$a0, $t1           # $t2 = address of array[i]
        sw      $zero,0($t2)           # array[i] = 0
        addi    $t0,$t0,1              # i = i + 1
        slt     $t3,$t0,$a1            # $t3 = (i < size)
        bne     $t3,$zero,loop1        # if (i < size) go to loop1
```

```
        move    $t0,$a0                # p = address of array[0]
        add     $t1,$a1,$a1            # $t1 = size * 2
        add     $t1,$t1,$t1            # $t1 = size * 4
        add     $t2,$a0, $t1           # $t2=address of array[size]
loop2:  sw      $zero,0($t0)           # Memory[p] = 0
        addi    $t0,$t0,4              # p = p + 4
        slt     $t3,$t0,$t2            # $t3 = (p < &array[size])
        bne     $t3,$zero,loop2        # if (p < &array[size]) go
                                       # to loop2
```

- The pointer version reduces the instructions executed per iteration from 7 to 4.

Reading assignment

- Read 2.6, 2.8, 2.10 (Linker), 2.13