Computer Architecture
Tutorial 07

MIPS Instruction Set

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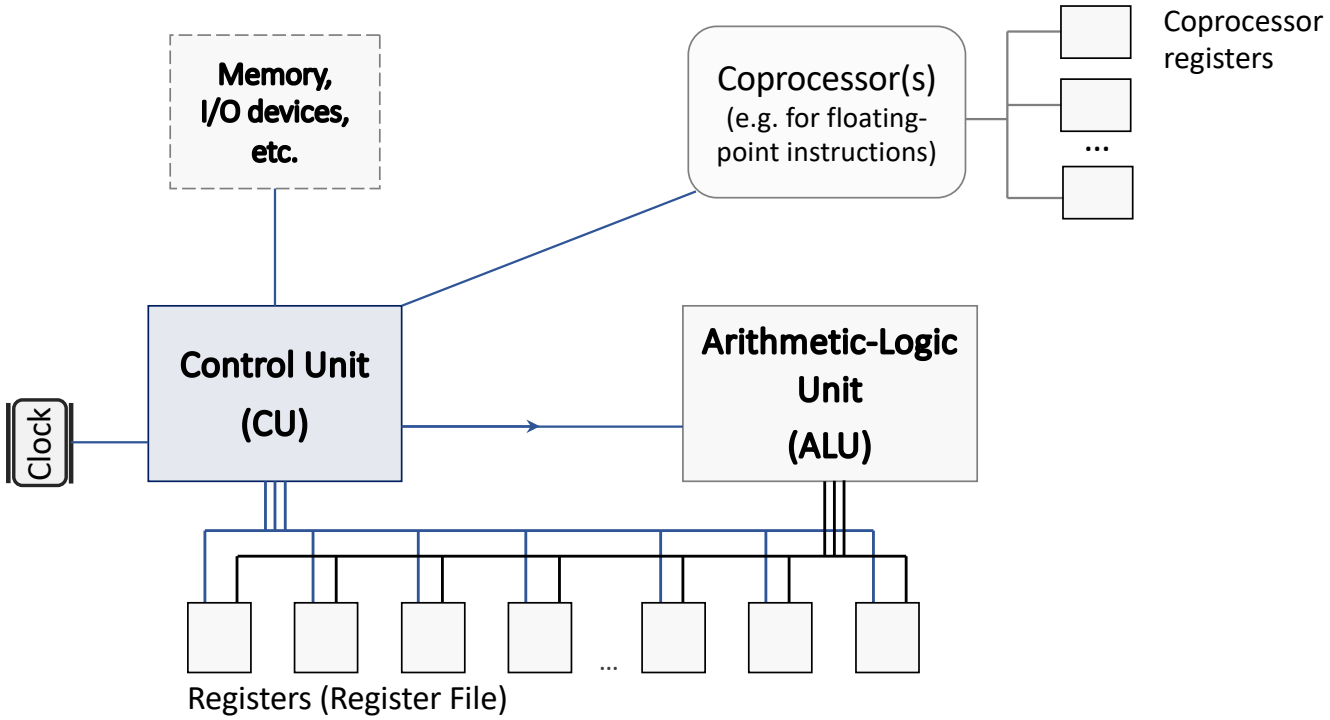
INNOPOLIS UNIVERSITY

MIPS Architecture Layout



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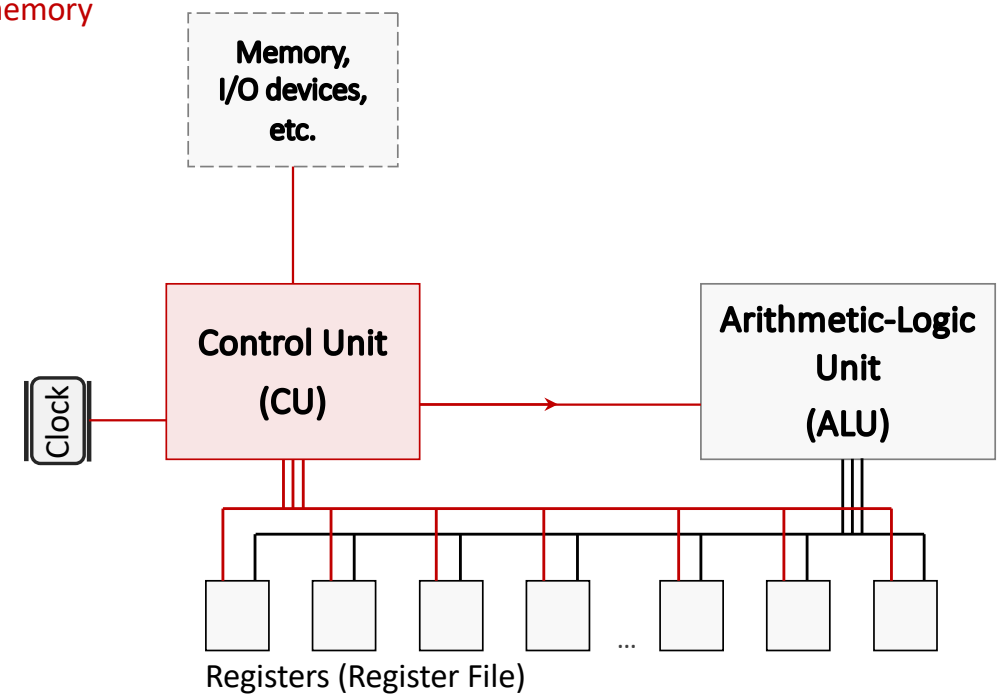

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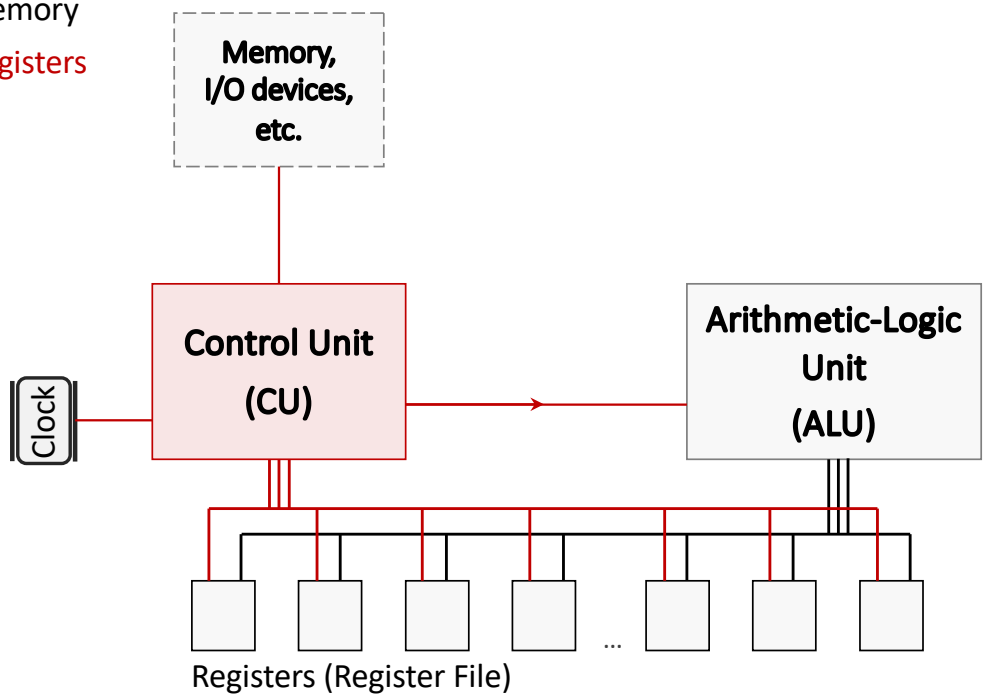

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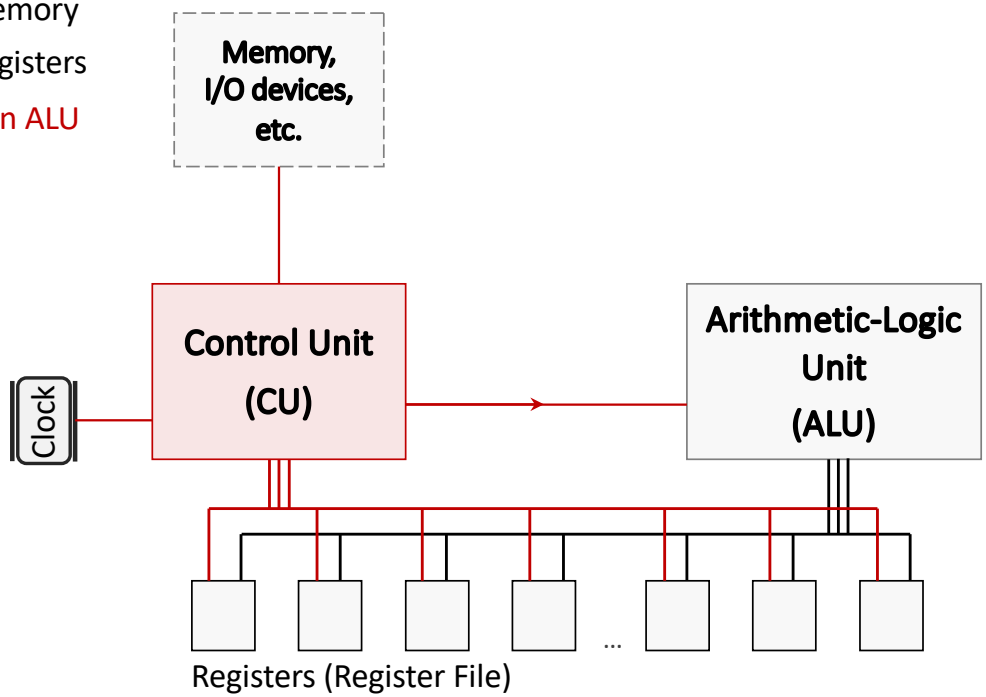

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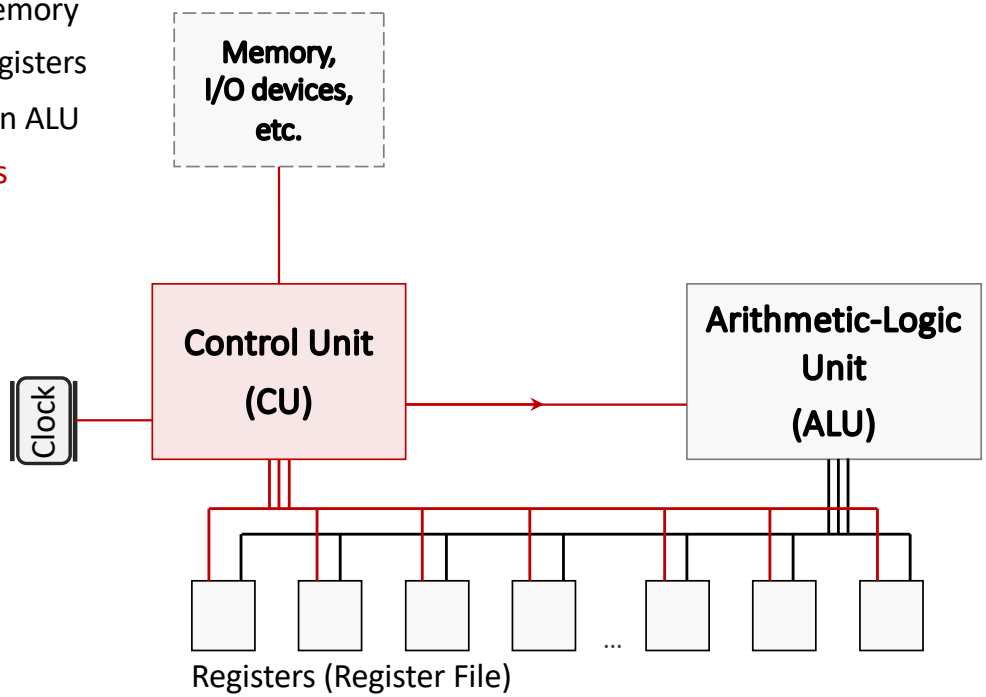

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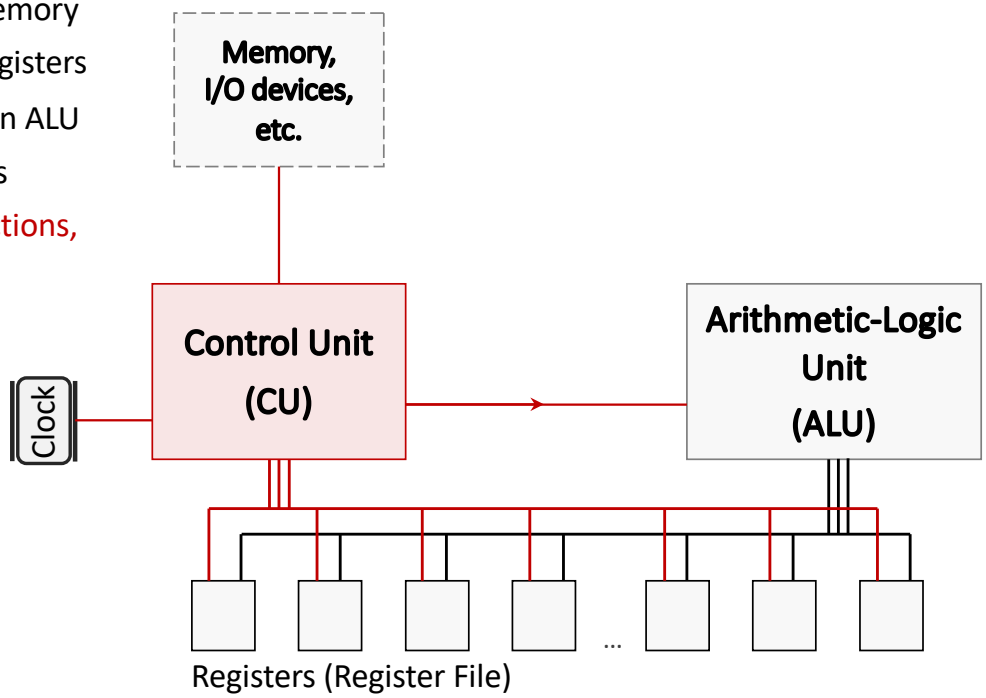

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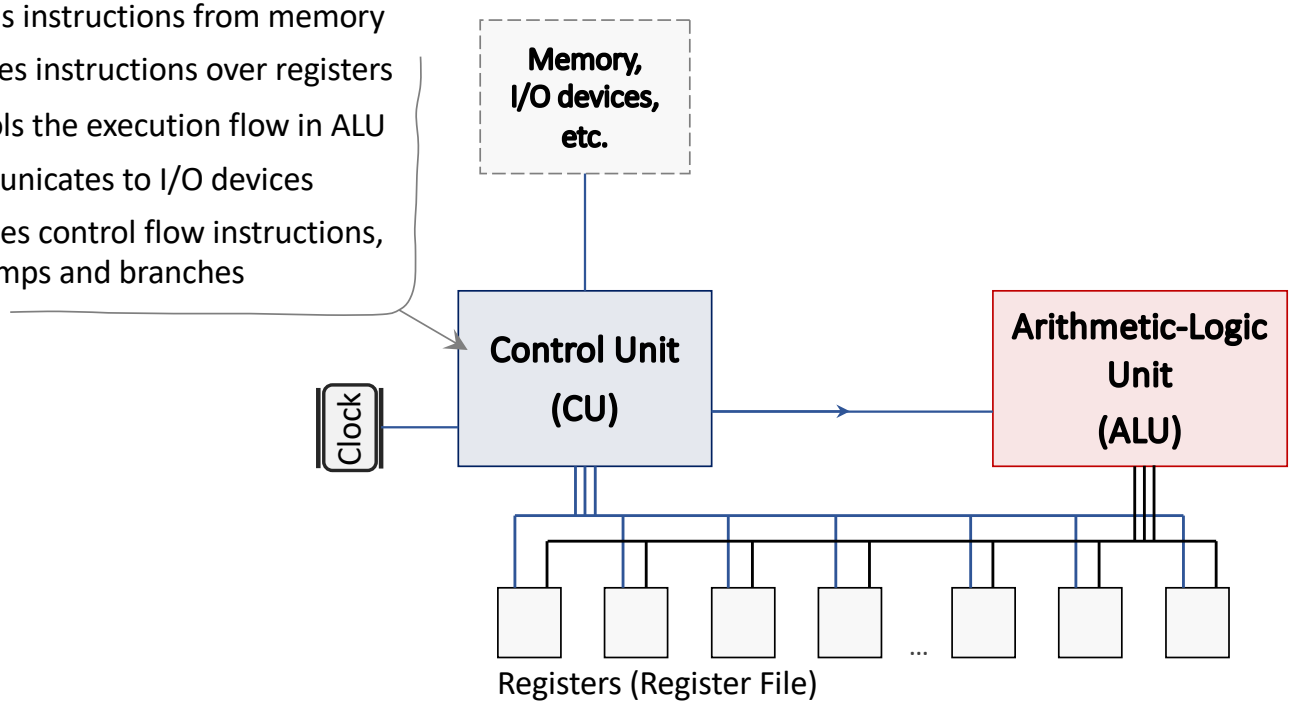

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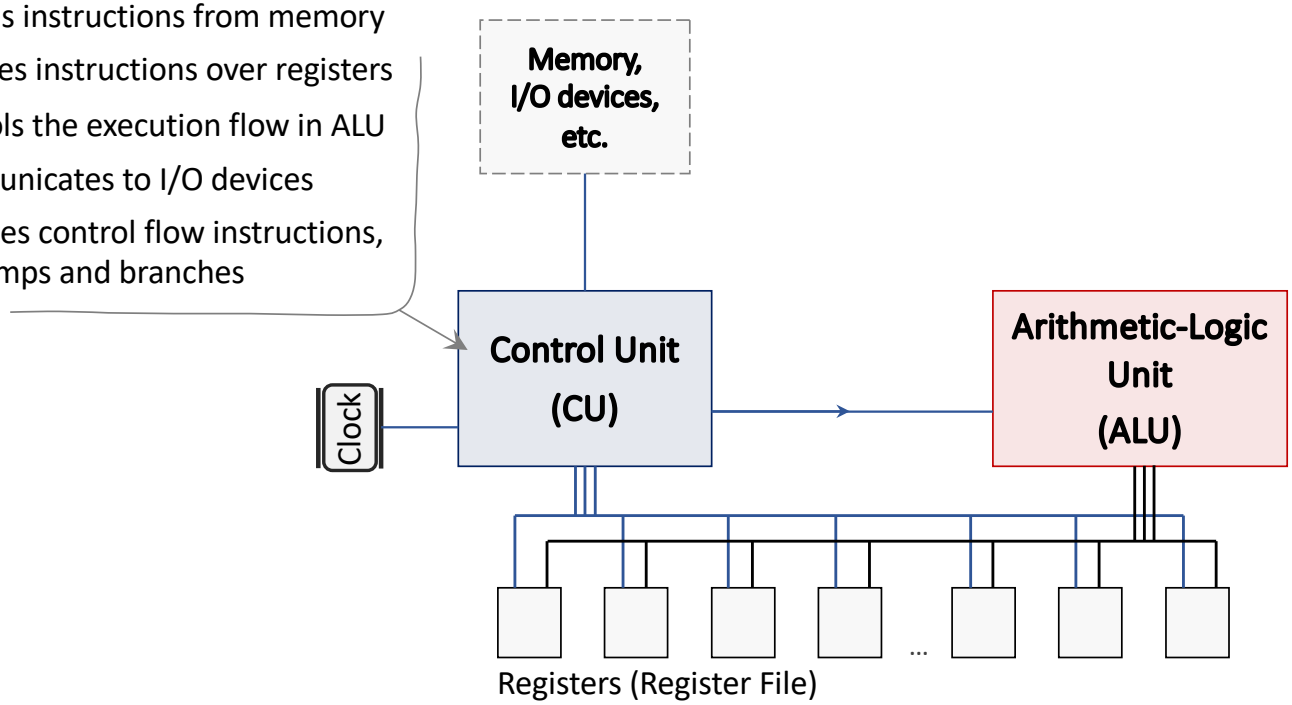

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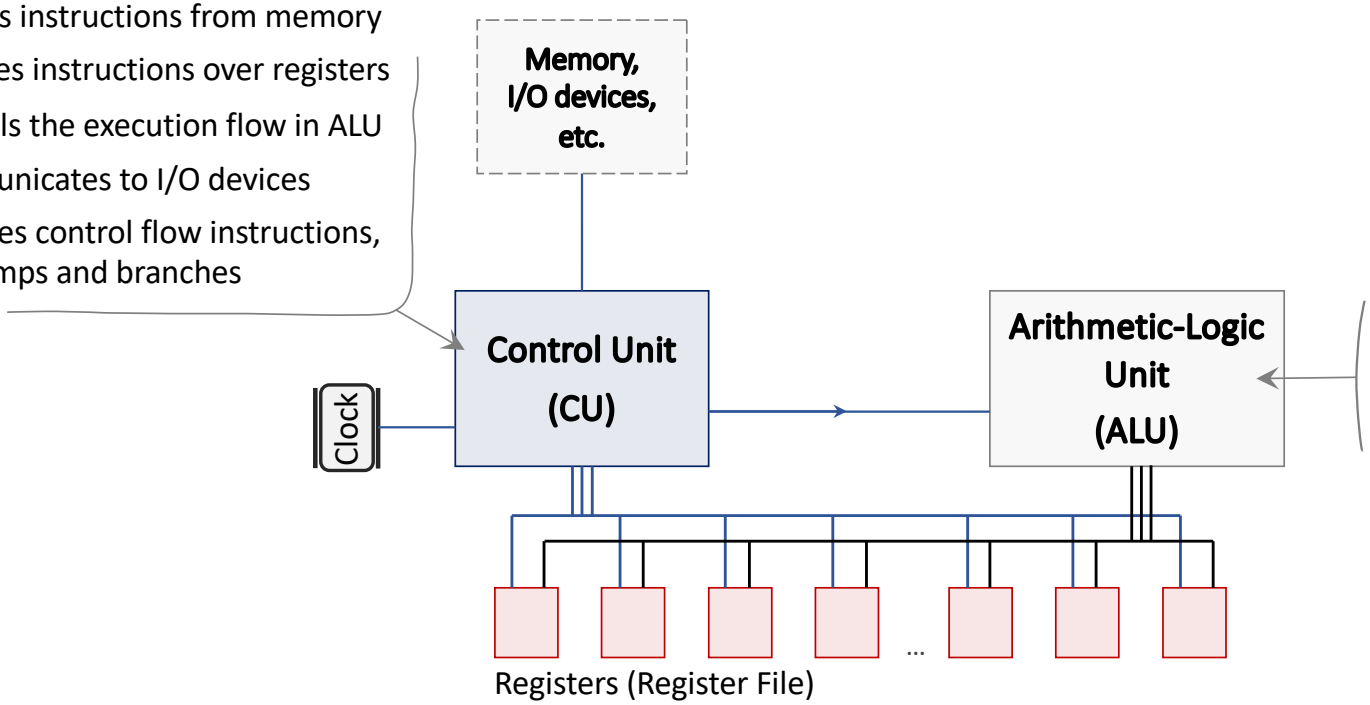

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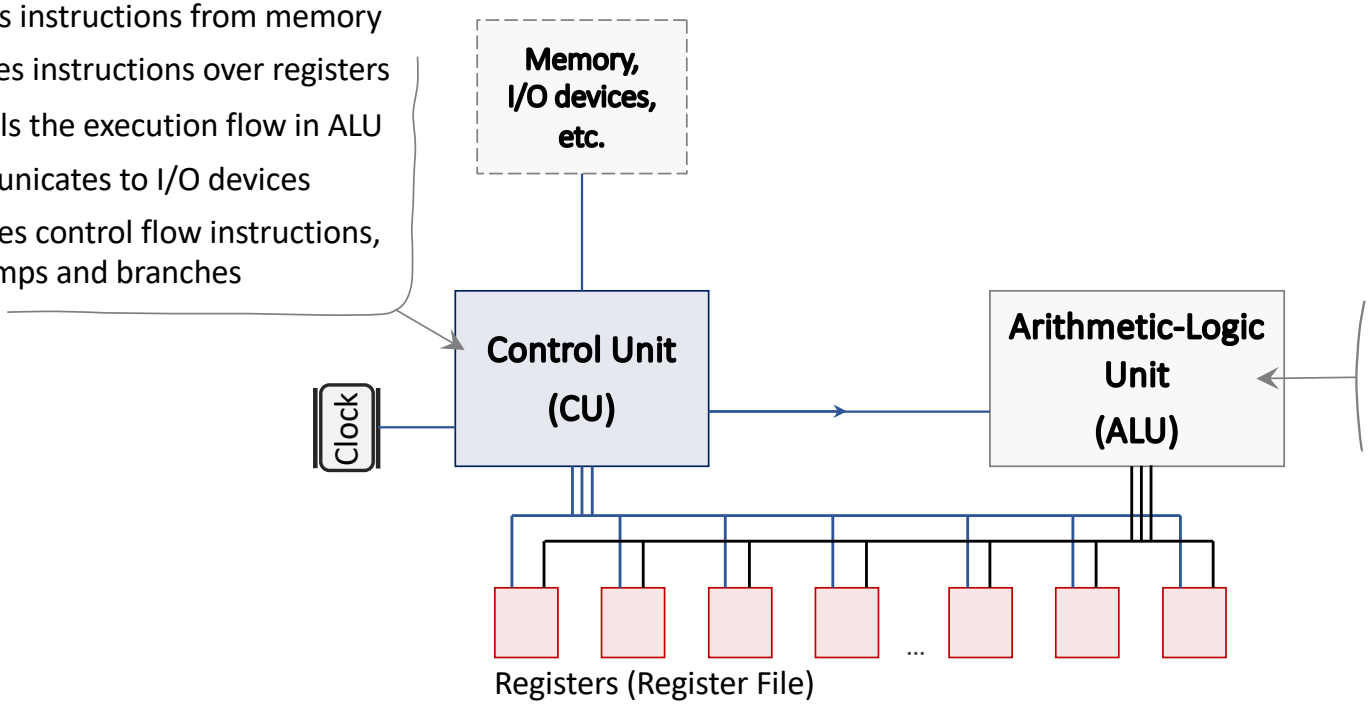

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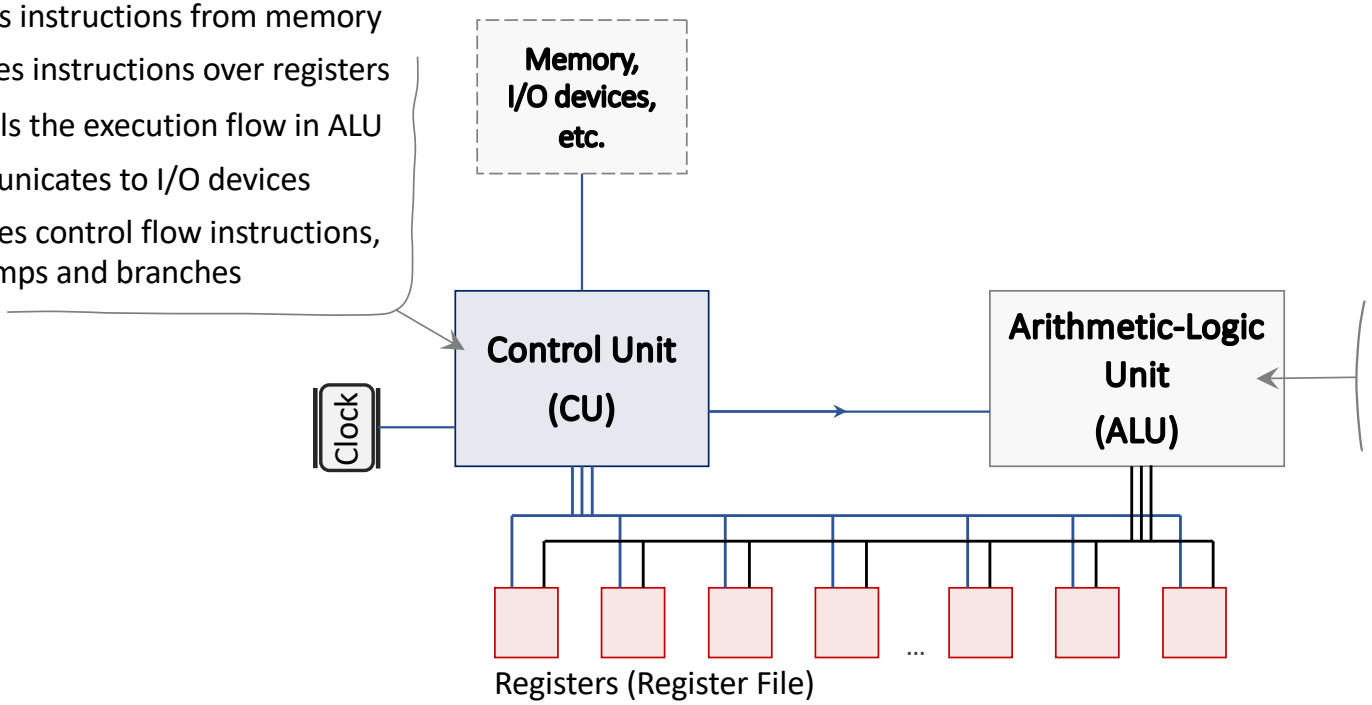

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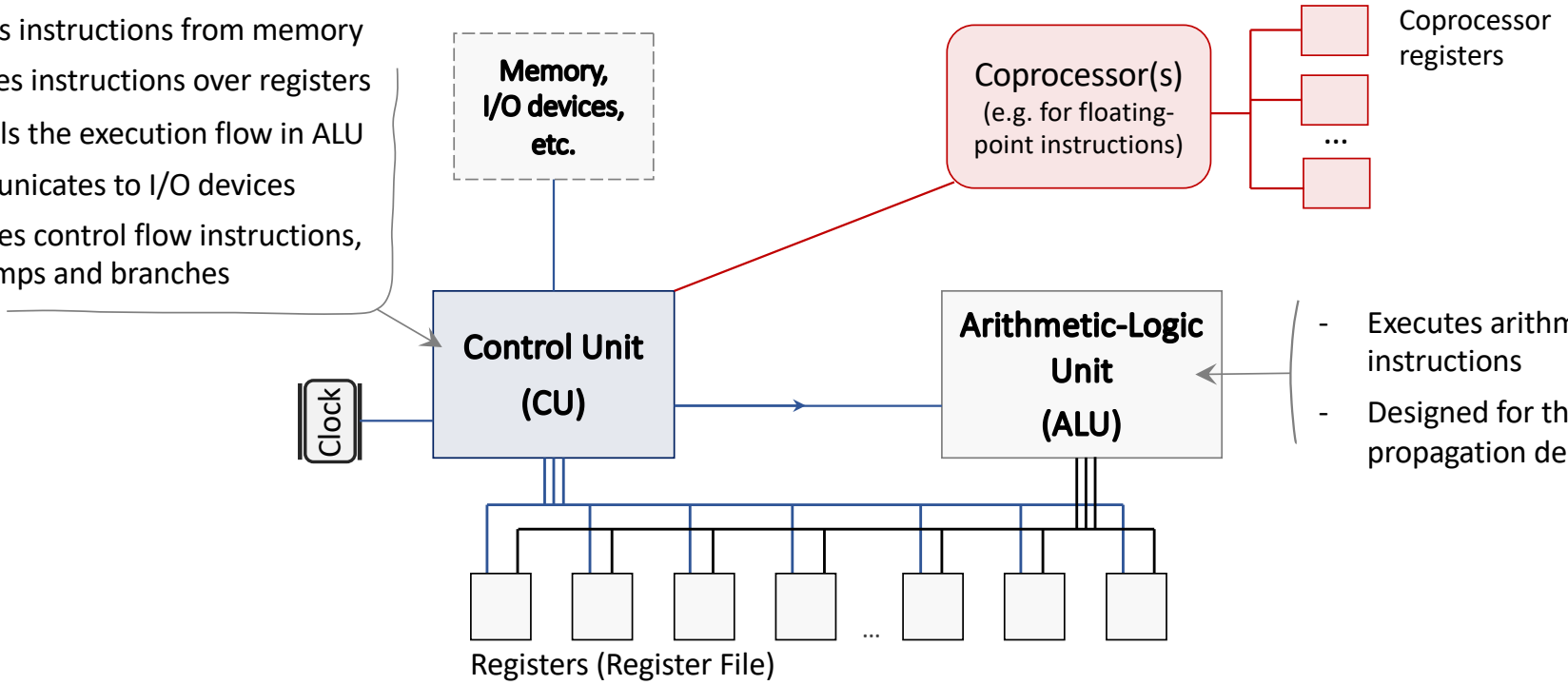

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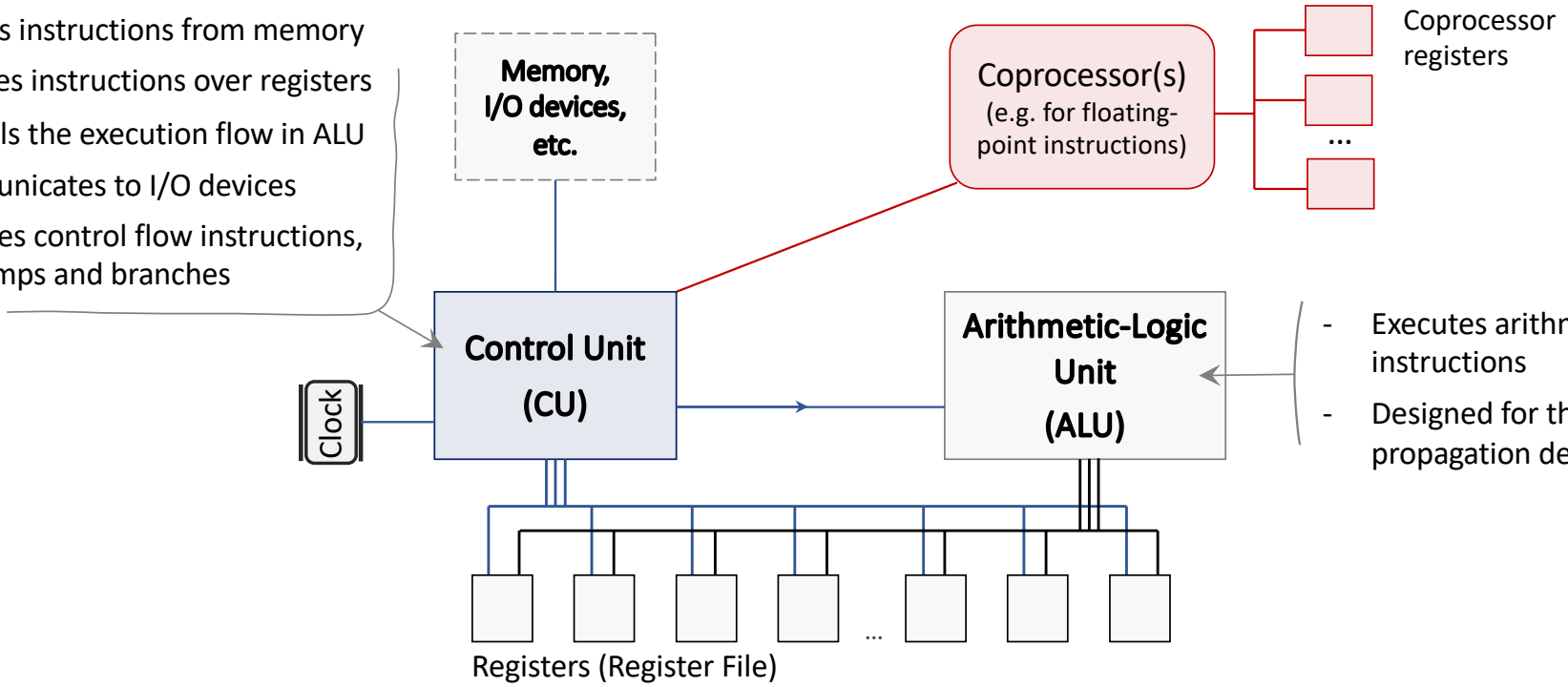

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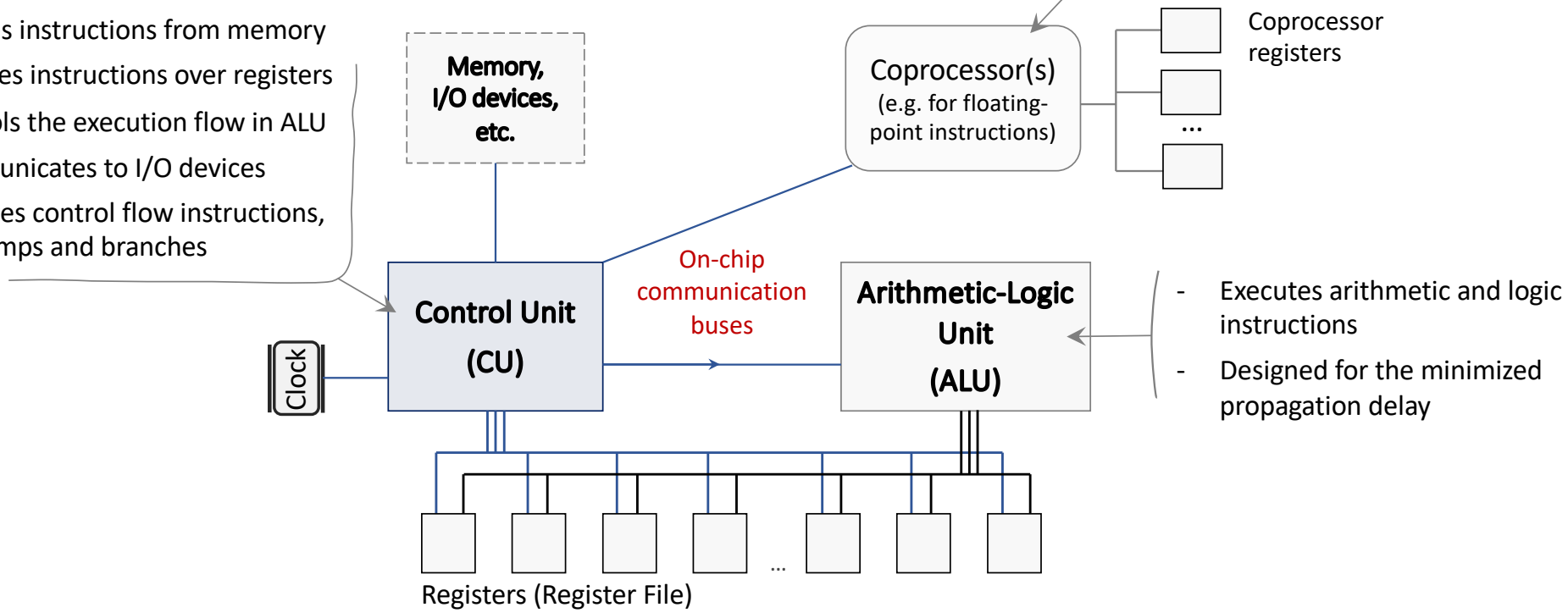

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Some Aspects Affecting the CPU Clock Frequency

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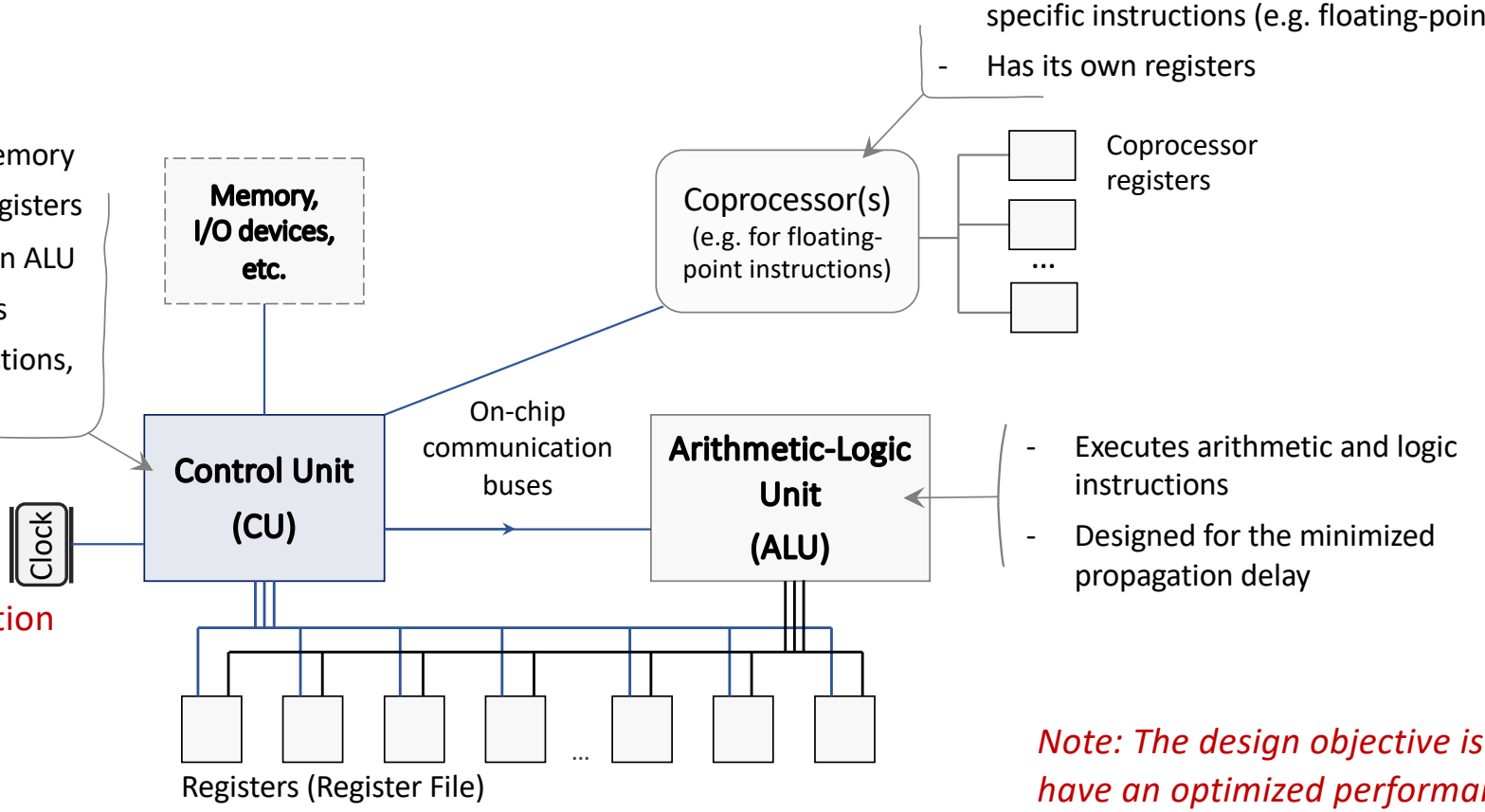

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The worst-case propagation delay of the slowest instruction drastically affects CPU clock frequency

The number of registers:

The worst-case propagation delay tends to increase for a larger number of registers

(due to longer wires, multiplexers with a larger number of inputs, etc.)

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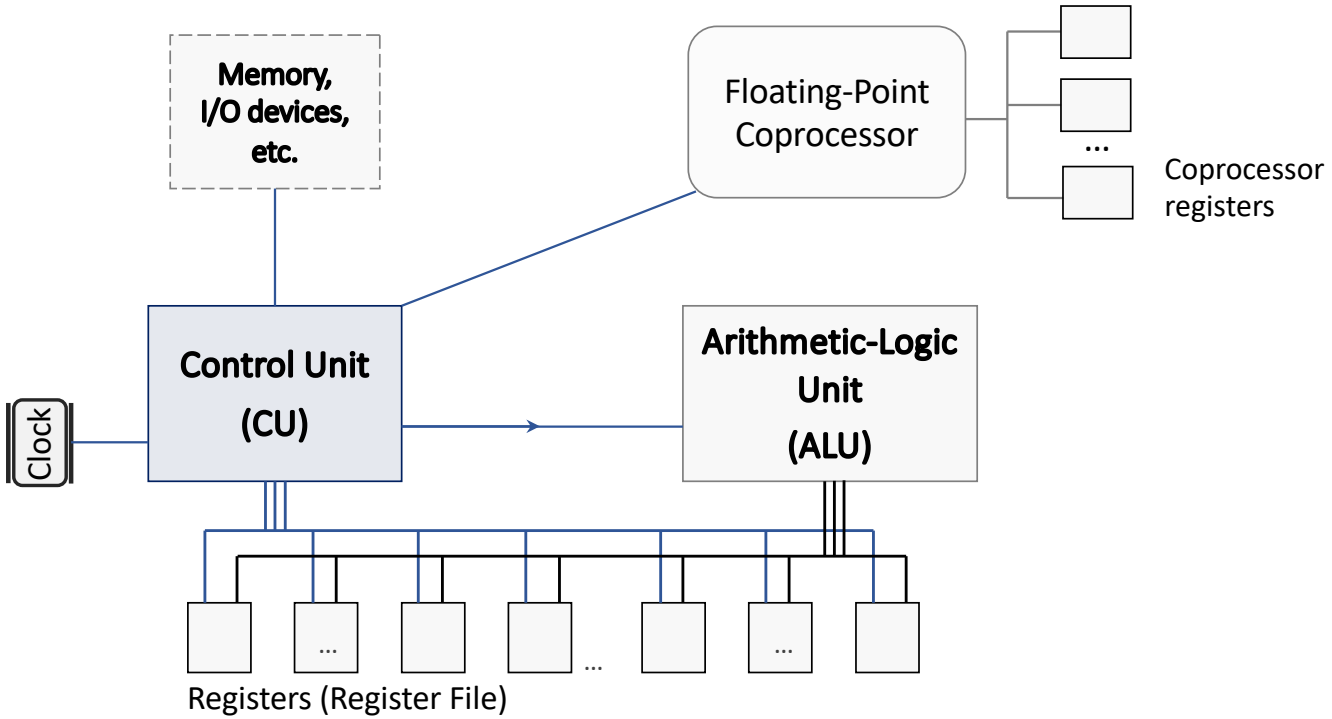
Note: The design objective is to have an optimized performance in the average use case, and not to have a higher number of instructions supported

(recall the difference between RISC and CISC)

MIPS Processor Architecture

MIPS is a RISC architecture



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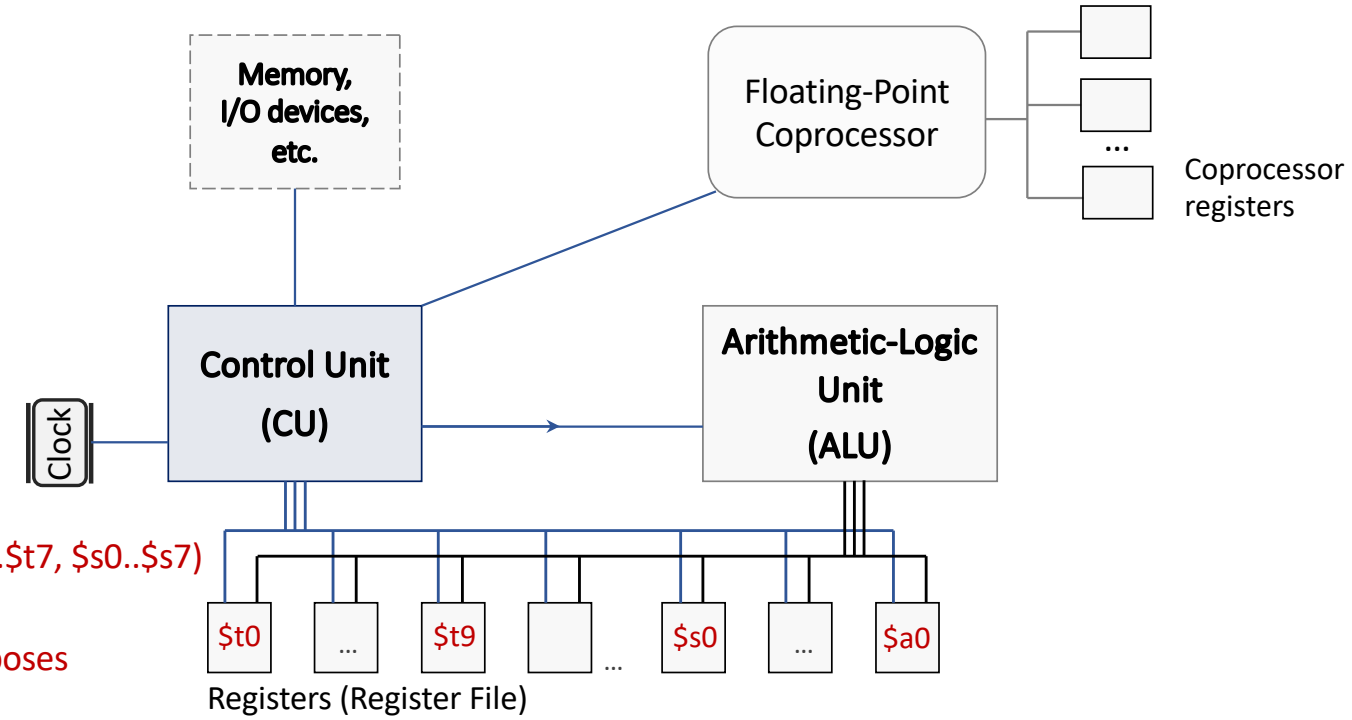

32 general-purpose registers:

- Have their names (like $t0..$t7, $s0..$s7)
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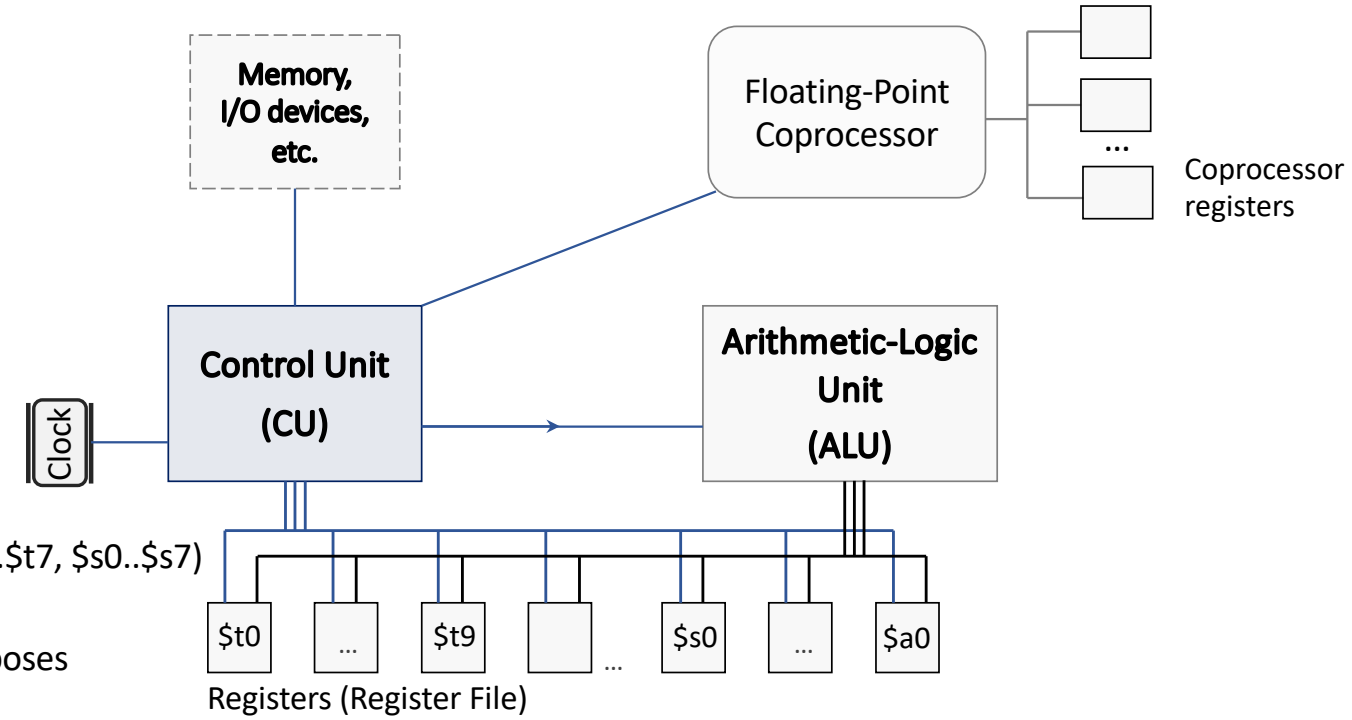

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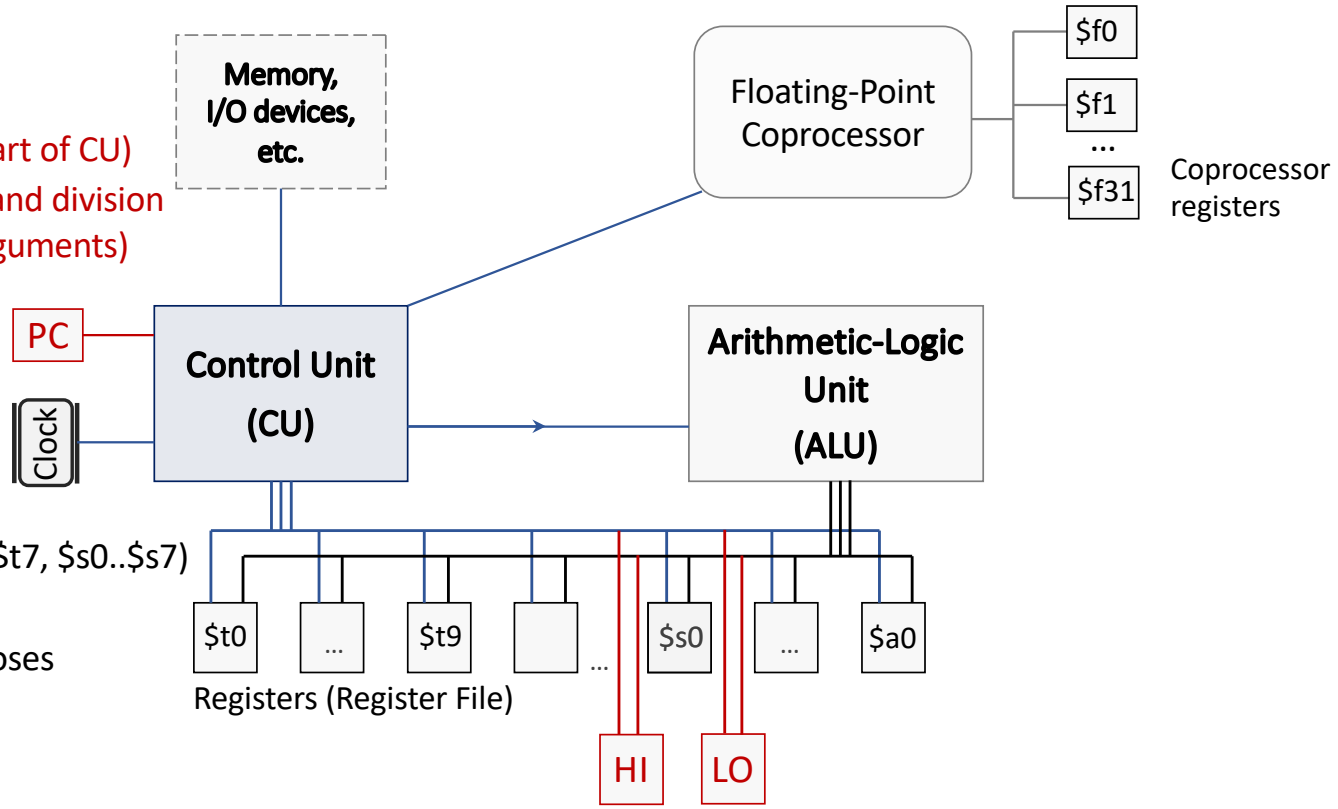
3 special-purpose registers:
- PC – program counter (a part of CU)
- HI, LO – for multiplication and division instructions (for integer arguments)



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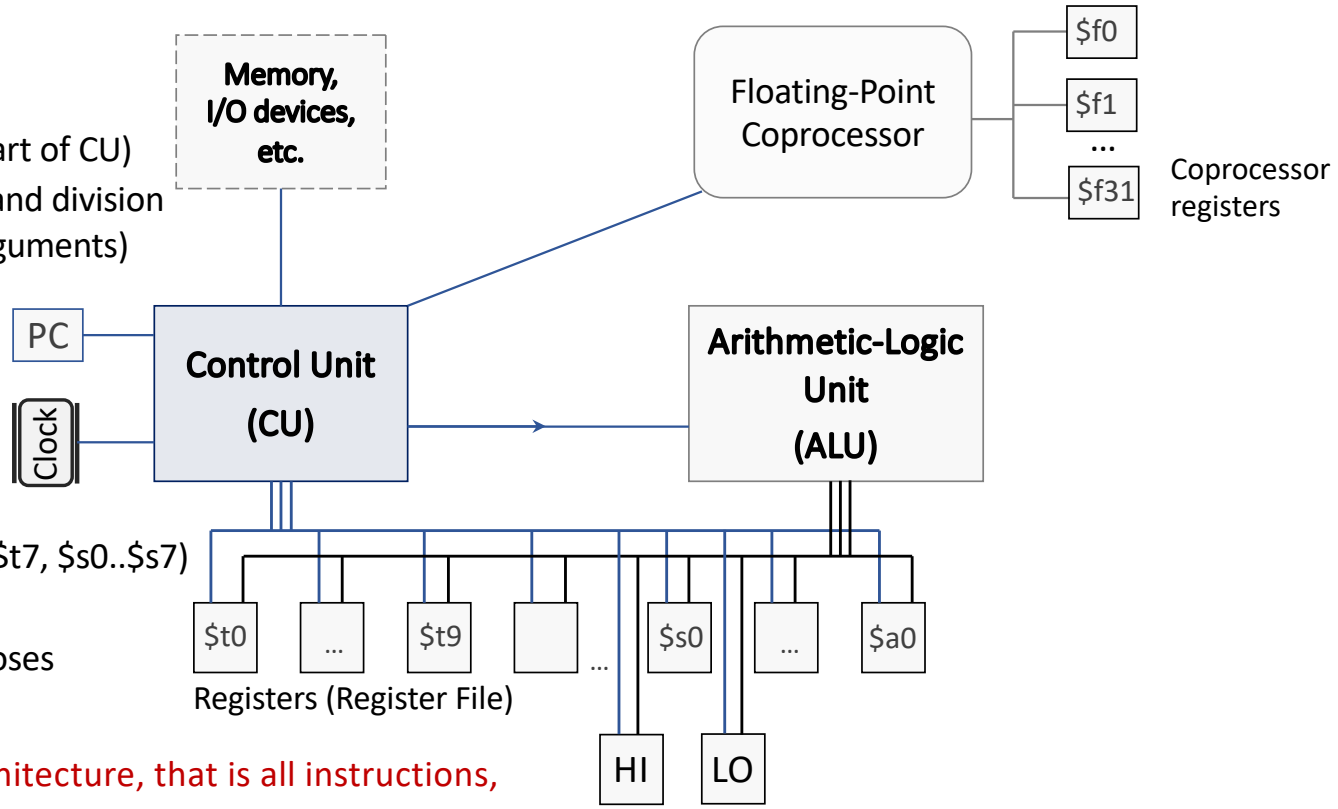

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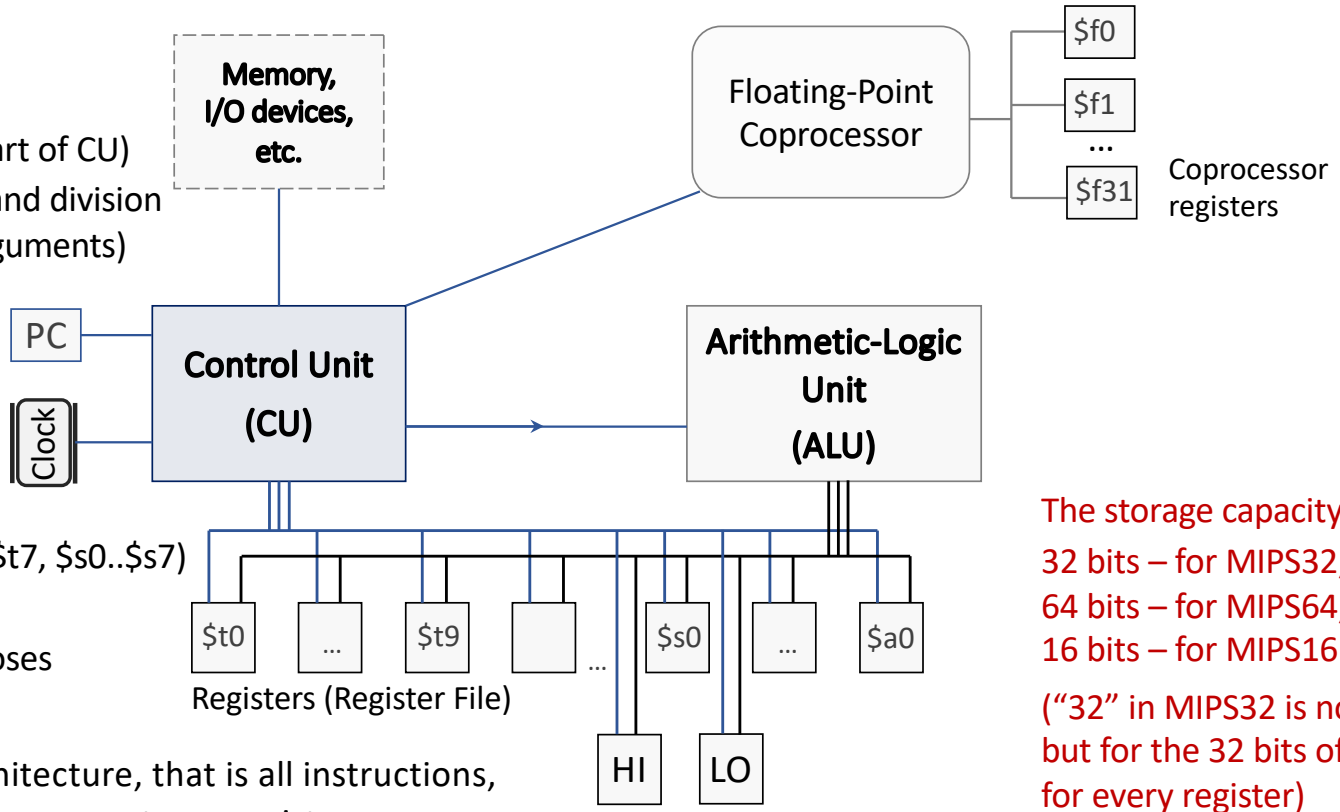

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The storage capacity of a register varies:
32 bits – for MIPS32;
64 bits – for MIPS64;
16 bits – for MIPS16

("32" in MIPS32 is not for 32 registers, but for the 32 bits of storage capacity for every register)

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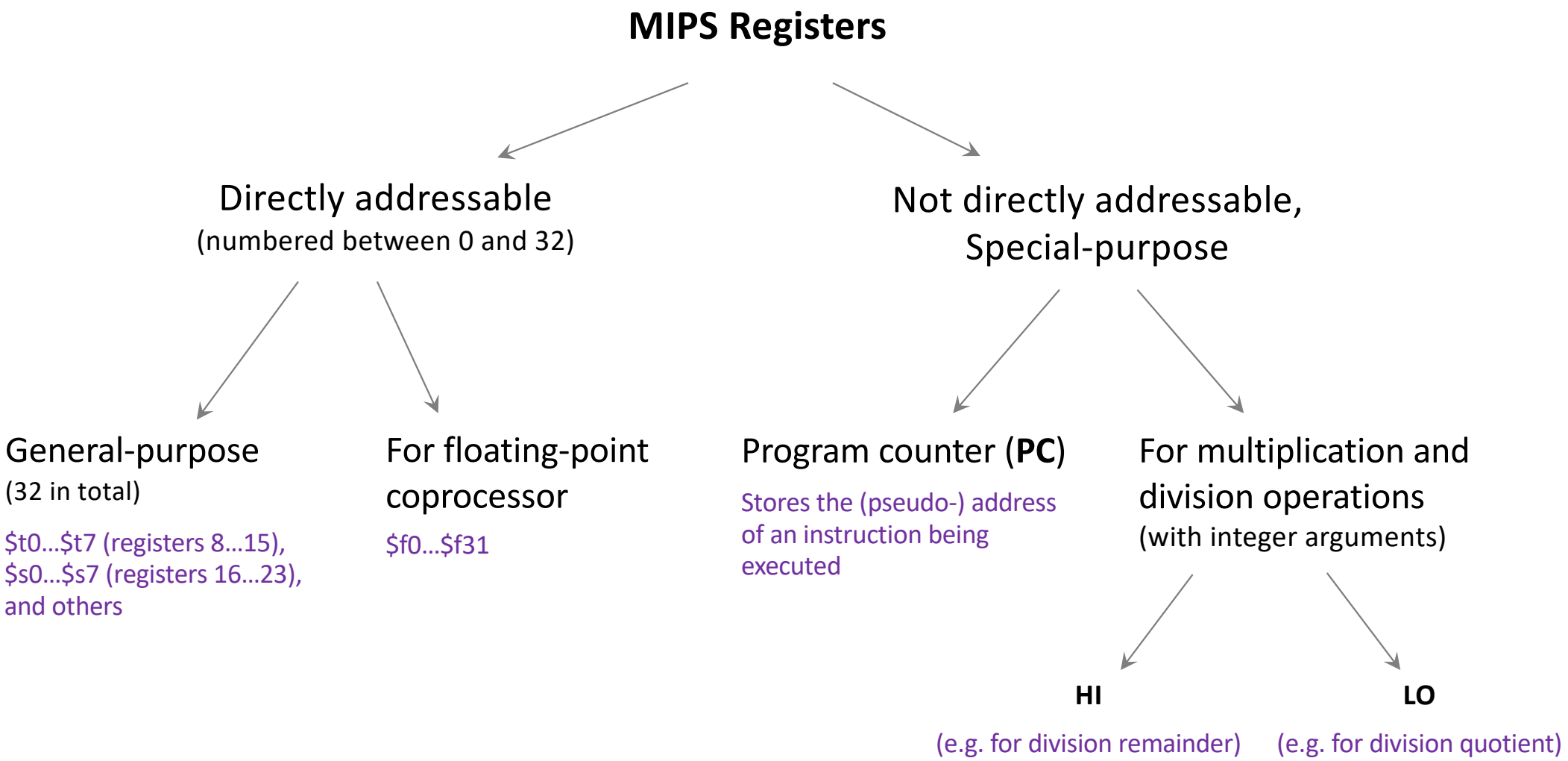
To provide flow control in a program


MIPS Registers
Directly addressable
(numbered between 0 and 32)
Not directly addressable,
Special-purpose
General-purpose
(32 in total)
$t0…$t7 (registers 8…15),
$s0…$s7 (registers 16…23),
and others
For floating-point
coprocessor
$f0…$f31
Program counter (PC)
Stores the (pseudo-) address
of an instruction being
executed
For multiplication and
division operations
(with integer arguments)
HI
(e.g. for division remainder)
LO
(e.g. for division quotient)

Sample MIPS Assembly Program: Addition of Two Numbers

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la – “load argument”, to load a constant string into some register

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Some available MIPS arithmetic and logic instructions:

Arithmetic	add	**add $t0, $t1, $t2**	$t0 = $t1 + $t2
	subtract	**sub $t0, $t1, $t2**	$t0 = $t1 - $t2
	add immediate	**addi $t0, $t1, 26**	$t0 = $t1 - 26
Logical (bitwise, that is bit by bit)	and	**and $t0, $t1, $t2**	$t0 = $t1 & $t2
	or	**or $t0, $t1, $t2**	$t0 = $t1 | $t2
	nor	**nor $t0, $t1, $t2**	$t0 = ~($t1 | $t2)
	and immediate	**andi $t0, $t1, 17**	$t0 = $t1 & 17
	or immediate	**ori $t0, $t1, 13**	$t0 = $t1 | 13
	shift left logical	**sll $t0, $t1, 4**	$t0 = $t1 << 4
	shift right logical	**srl $t0, $t1, 6**	$t0 = $t1 >> 6

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	subtract	**sub $t0, $t1, $t2**	$t0 = $t1 - $t2
	add immediate	**addi $t0, $t1, 26**	$t0 = $t1 - 26
Logical (bitwise, that is bit by bit)	and	**and $t0, $t1, $t2**	$t0 = $t1 & $t2
	or	**or $t0, $t1, $t2**	$t0 = $t1 | $t2
	nor	**nor $t0, $t1, $t2**	$t0 = ~($t1 | $t2)
	and immediate	**andi $t0, $t1, 17**	$t0 = $t1 & 17
	or immediate	**ori $t0, $t1, 13**	$t0 = $t1 | 13
	shift left logical	**sll $t0, $t1, 4**	$t0 = $t1 << 4
	shift right logical	**srl $t0, $t1, 6**	$t0 = $t1 >> 6

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3		
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4   move  $a0, $t0      # move value from register $t0 to $a0
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4  move  $a0, $t0      # move value from register $t0 to $a0
5  li  $v0, 1          # set code for syscall to "1" (to print)
```

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1  li  $t1, 5              # load value "5" into register $t1
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4  move  $a0, $t0          # move value from register $t0 to $a0
5  li  $v0, 1              # set code for syscall to "1" (to print)
6  syscall                 # execute syscall with code in $v0 and argument in $a0
```

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We are ready to exit the program

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5  li  $v0, 1              # set code for syscall to "1" (to print)
6  syscall                 # execute syscall with code in $v0 and argument in $a0
7  li  $v0, 10             # set code for syscall to "10" (exit)
```

Code in $v0	Purpose	Arguments/Return values
10	Exit program	None

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4  move  $a0, $t0          # move value from register $t0 to $a0
5  li  $v0, 1              # set code for syscall to “1” (to print)
6  syscall                 # execute syscall with code in $v0 and argument in $a0
7  li  $v0, 10             # set code for syscall to “10” (exit)
8  syscall                 # execute syscall with code “10”
```

Another Example: Reading and Printing a String

```
1   . data
```

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Possible MIPS assembly directives:
.data
.text
.globl

Another Example: Reading and Printing a String

```
1   . data
2       msg:        .asciiz “Enter your string: ”        # message asking to input a string
```

Another Example: Reading and Printing a String

```
1   . data
2       msg:        .asciiz “Enter your string: ”       # message asking to input a string
4       inputStr:   .space 10                           # array of 10 bytes, to store input string
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2       msg:        .asciiz “Enter your string: ”        # message asking to input a string
4       inputStr:   .space 10                            # array of 10 bytes, to store input string
5   main:
6       li $v0, 4                    # syscall code to print message asking to input a string
```

Codes of system calls:

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1	Print integer	$a0 contains value to be printed
2	Print float	$f12 contains float value to be printed
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5   main:
6       li $v0, 4                  # syscall code to print message asking to input a string
7       la $a0, msg1               # load memory address of the beginning of a string
8       syscall                    # syscall invocation, to print message
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6       li $v0, 4                   # syscall code to print message asking to input a string
7       la $a0, msg1                # load memory address of the beginning of a string
8       syscall                     # syscall invocation, to print message
9       li $v0, 8                   # syscall code to read string from user
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9       li $v0, 8                   # syscall code to read string from user
10      la $a0, inputStr            # memory address, where to start writing an input string
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9       li $v0, 8                   # syscall code to read string from user
10      la $a0, inputStr            # memory address, where to start writing an input string
11      li $a1, 10                  # the maximum size of an input string
12      syscall                     # syscall to read string; $v0 now “contains” a user string
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12      syscall                     # syscall to read string; $v0 now “contains” a user string
13      move $a0, $v0               # move string address from $v0 to $a0
14      li $v0, 4                   # syscall code to print a string
15      li $a1, 10                  # the size of a string to be printed
16      syscall                     # printing string
```

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14      li $v0, 4                   # syscall code to print a string
15      li $a1, 10                  # the size of a string to be printed
16      syscall                     # printing string
17      li $v0, 10                  # syscall code to terminate the program
18      syscall                     # termination
```