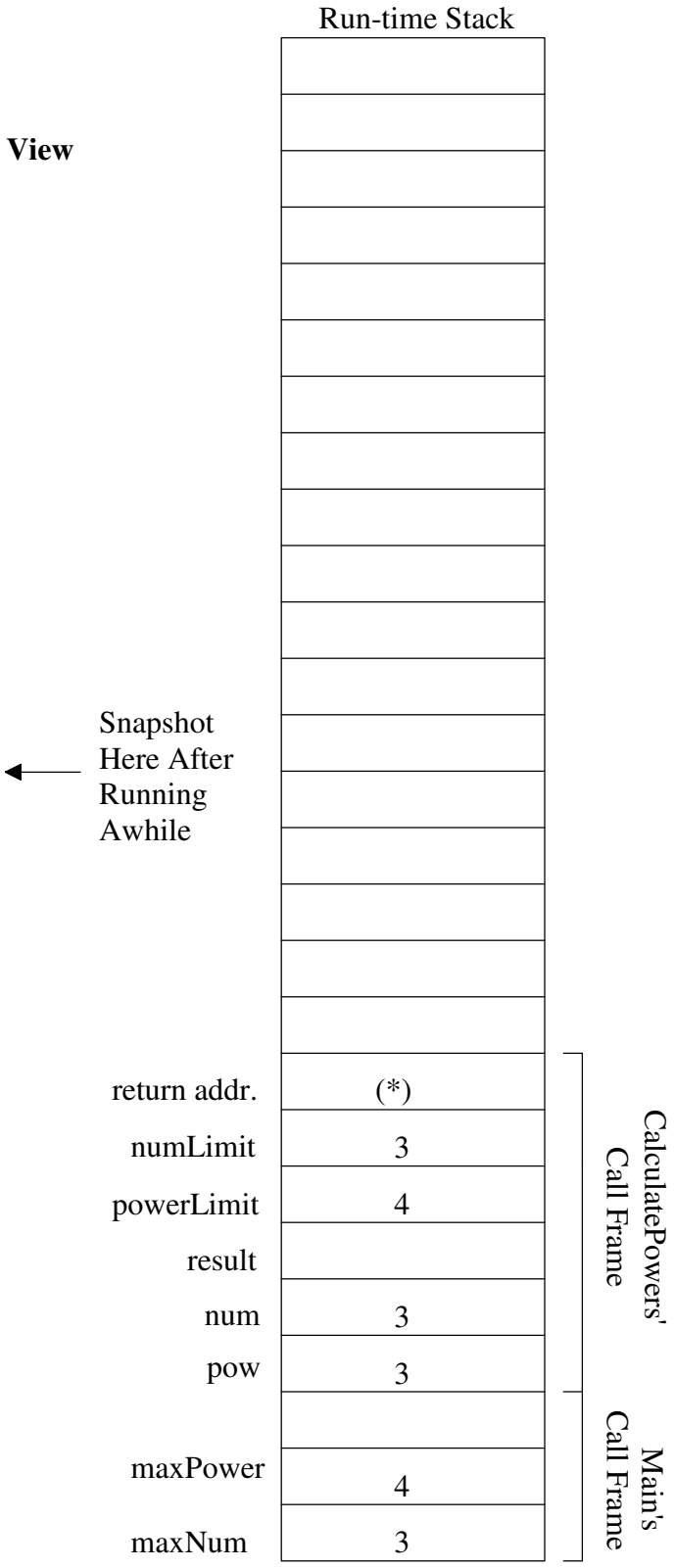
Name:_____

High-level Language Programmer's View

```
main:
maxNum = 3
maxPower = 4

CalculatePowers(maxNum, maxPower)
(*)
. . .
end main


CalculatePowers(In: integer numLimit,
                integer powerLimit)
integer num, pow, result

for num := 1 to numLimit do
    for pow := 1 to powerLimit do
        Power(num, pow, result)
(**)    print num " raised to " pow " power is "
                result
    end for pow
end for num

end CalculatePowers


Power( In:  integer n, integer e, Out: result)

if e = 0 then
    result = 1
else if e = 1 then
    result = n
else
    Power(n, e - 1, result)
    result = result * n          (***)
end if

end Power
```



1) Trace the next execution of the recursive function Power by showing the run-time stack.

2) What is the most number of call frames on the stack at any one time for the **whole** program?

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RISC Assembly-language Programmer's View

3) Trace the hypothetical assembly language program and indicate the resulting value of the registers Reg1, Reg2, Reg3, and Reg4.

```
        .data                                       ; Variables setup in MEMORY before execution
X:      .WORD       2                               ; variable X initialized at assembly time to 2
Y:      .WORD       3                               ; variable Y initialized at assembly time to 3
Z:      .WORD       0                               ; variable Z initialized at assembly time to 0

        .program
Begin:
        LOAD Reg1, X                                ; loads X's value into register Reg1
        LOAD Reg2, Y
        ZERO  Reg3                                  ; sets Reg3's value to 0
        MOVE Reg4, Reg2                             ; Reg4 := Reg2
Loop:
        ADD   Reg3, Reg3, Reg1                      ; Reg3 := Reg3 + Reg1
        SUB_IMMEDIATE  Reg4, Reg4, #1               ; Reg4 := Reg4 - 1
        BRANCH_GREATER_THAN_ZERO Reg4, Loop         ; if Reg4 > 0 then goto Loop label
        STORE  Reg3, Z                              ; store Reg3's value into variable Z
End:
```

	Reg1	Reg2	Reg3	Reg4
Resulting register values				

a) What is the resulting value in Z?

b) What calculation does this code perform?

4) During the execution of the above assembly language code: (Assuming no cache)

a) How many memory reads were performed? (state any assumptions)

data reads =

instruction reads (assume one read per instruction fetch) =

b) How many memory writes were performed? (state any assumptions)

5) List (in decreasing order of importance) why somebody would write assembly language code.

(top reason) a)

b)

c)

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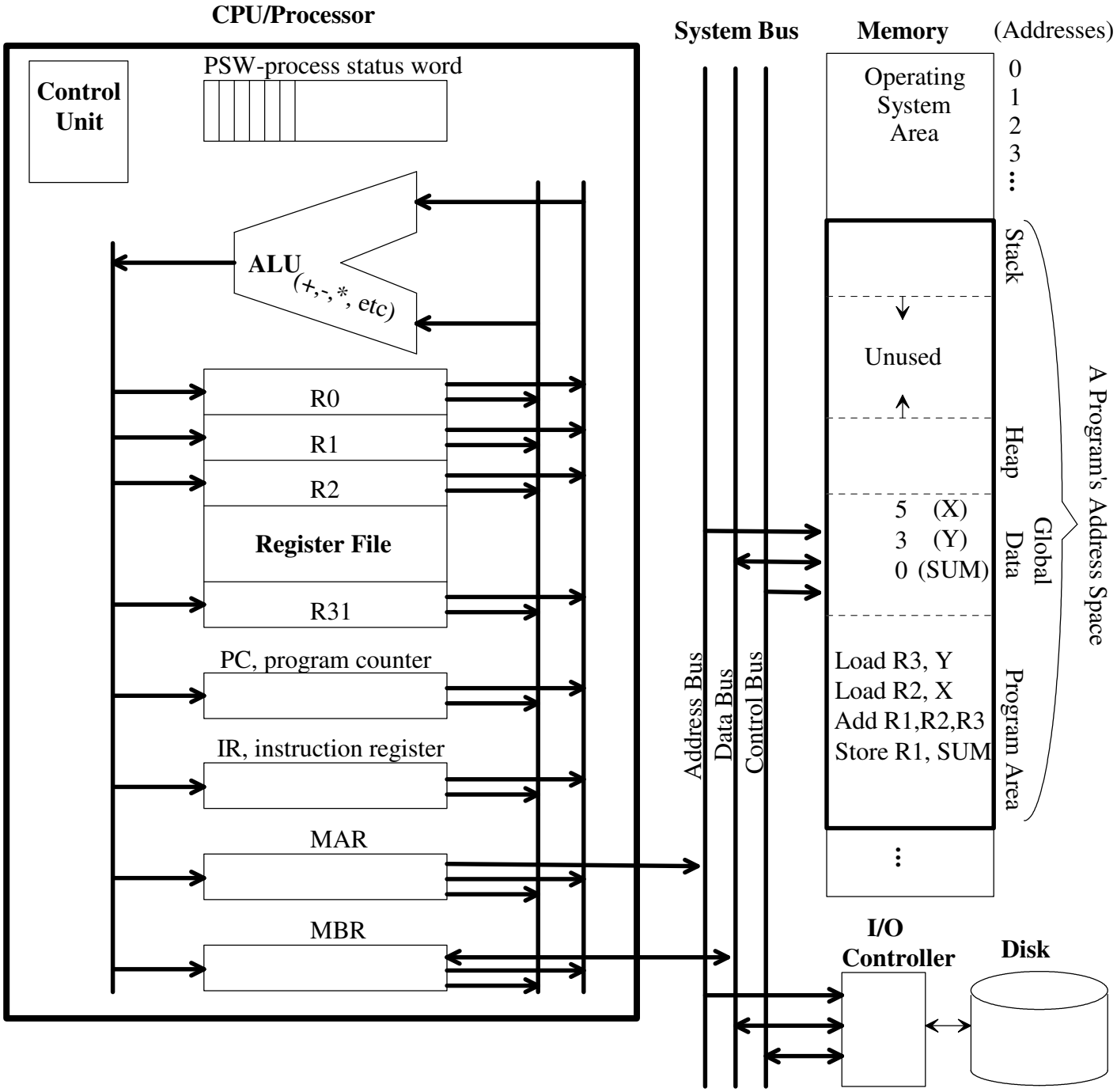

Instruction/Machine Cycle of stored-program computer - repeat all day

1. Fetch Instruction - read instruction pointed at by the program counter (PC) from memory into Instr. Reg. (IR)
2. Decode Instruction - figure out what kind of instruction was read
3. Fetch Operands - get operand values from the memory or registers
4. Execute Instruction - do some operation with the operands to get some result
5. Write Result - put the result into a register or in a memory location

6) What has to happen to the PC during the instruction cycle?

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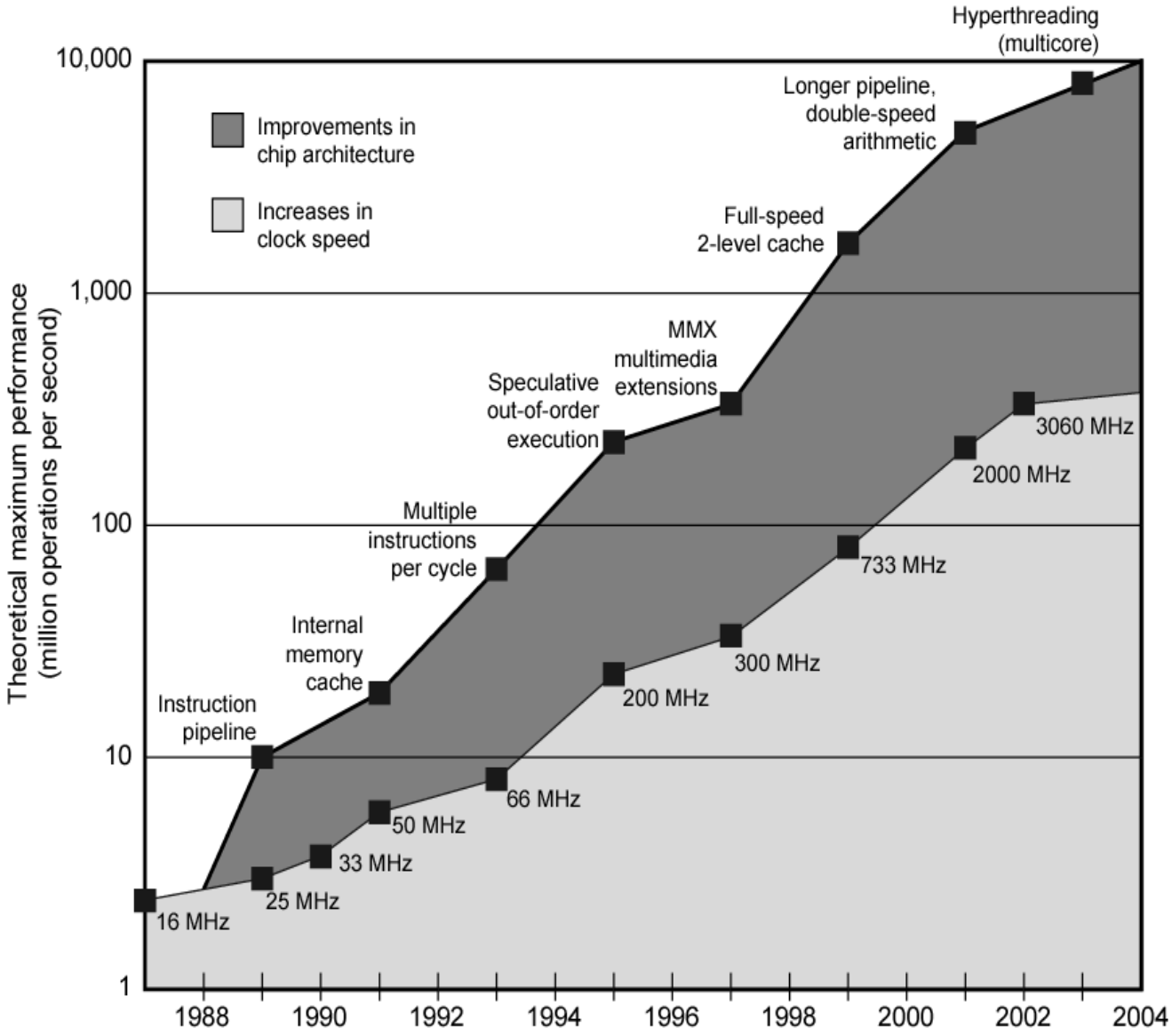
7) "Moore's law" (Gordon Moore - cofounder of Intel) - predicts that the number of transistors that could be put on a single chip would double every year (later changed to 18 months).

a) What kind of curve (# transistors vs. time) does Moore's law predict? (linear, quadratic, exponential, etc.)

b) As gate density increases on a chip, why would clock speed increase?



8) From the above graph, what architectural improvements seem to have the biggest impact on performance?