Topic V33

Cache Performance

Reading: (Section 5.4)

Measuring Cache Performance

Components of CPU time

- Program execution cycles
  - Includes cache hit time
- Memory stall cycles
  - Mainly from cache misses

$$\text{CPU time} = (\text{CPU cycles} + \text{Mem. stall cycles}) \times \text{cycle time}$$

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$$\text{Mem. stall cycles} = \frac{\#\text{ of Memory accesses}}{\text{Program}} \times \text{Miss rate} \times \text{Miss penalty}$$

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Memory Accesses

There are two sources of memory access in a program

- Instruction fetching
- Data load/store (from load/store instructions)

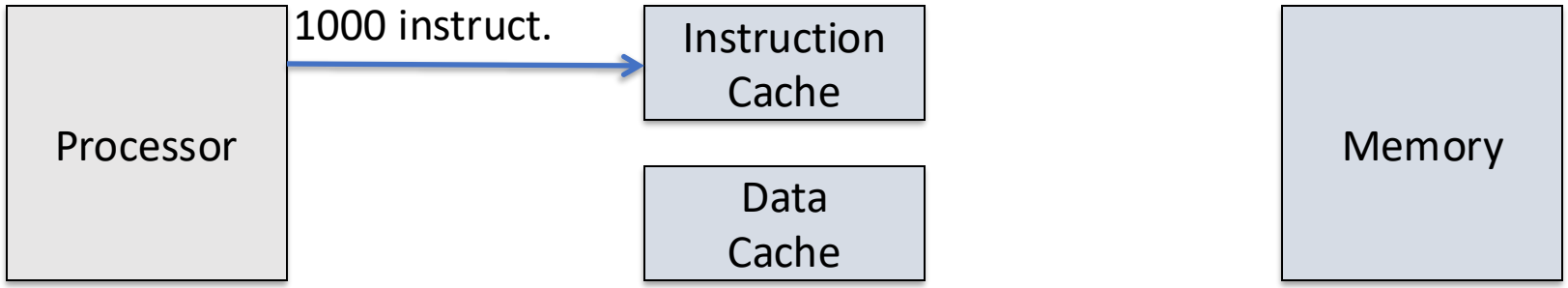
Unified cache

Data and instruction in the same cache (L2, L3, …)

Split cache

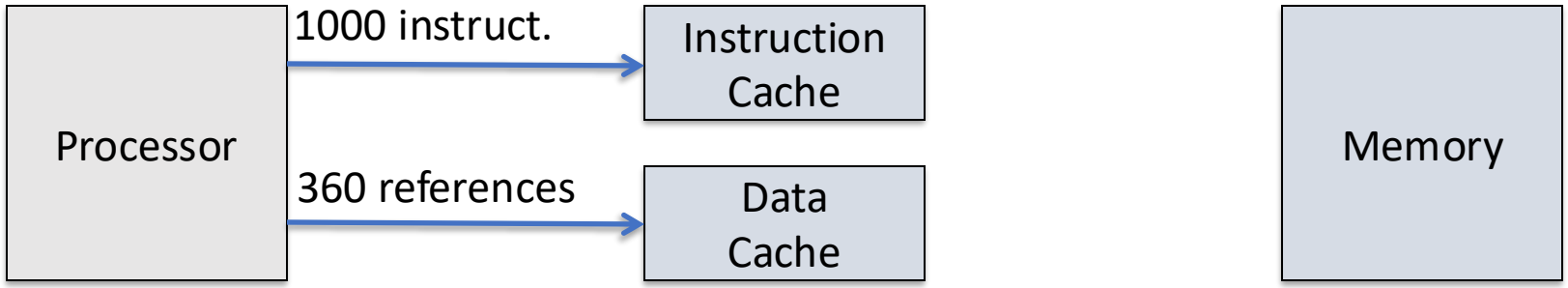
Possibly different miss rates for Data cache (Dcache) and Instruction cache (Icache

Calculating Cache Performance (example)



Calculating Cache Performance (example)

Assume that the miss rate of an instruction cache is 2% and that the miss rate of the data cache is 4%. If the processor has a CPI of 2 without any memory stalls and the miss penalty is 100 cycles for all misses, determine how much faster a processor would run with a perfect cache that never missed. Assume the frequency of all loads and stores is 36%.



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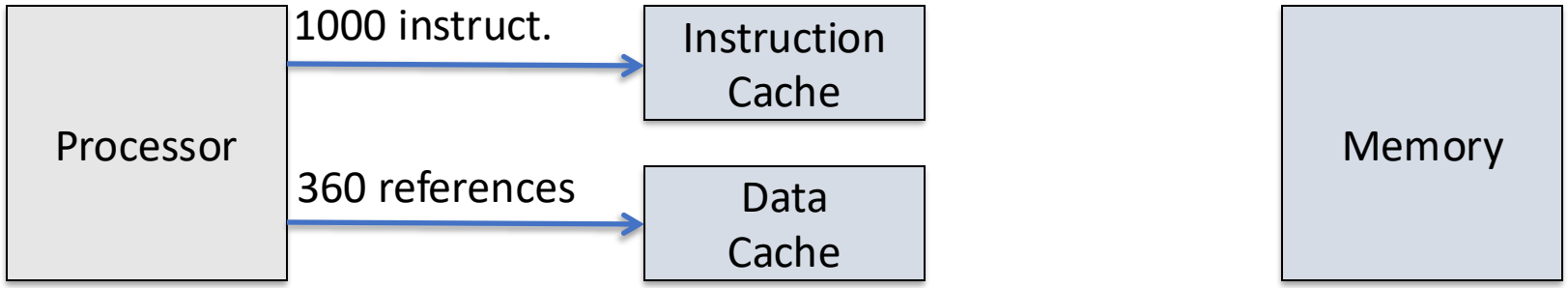

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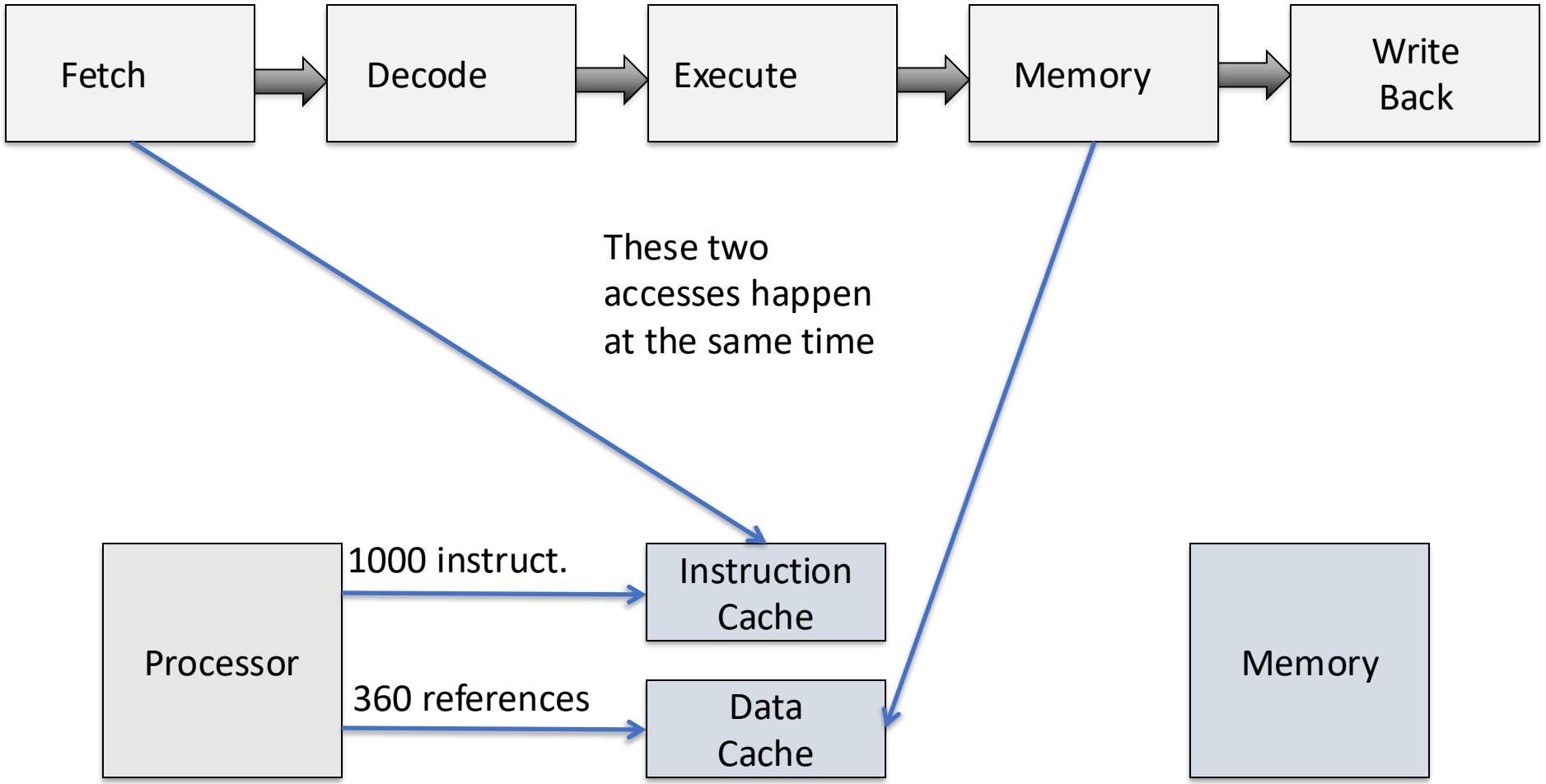

Without Memory Stalls: 2000 cycles

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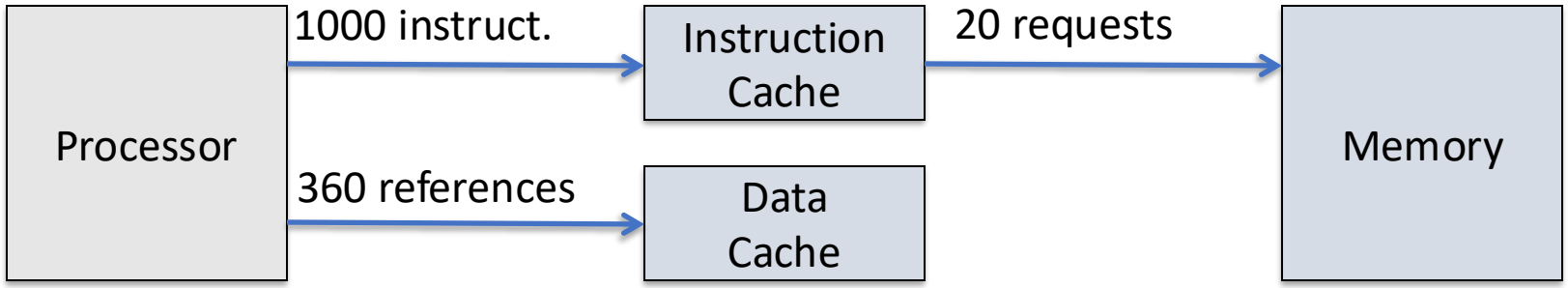

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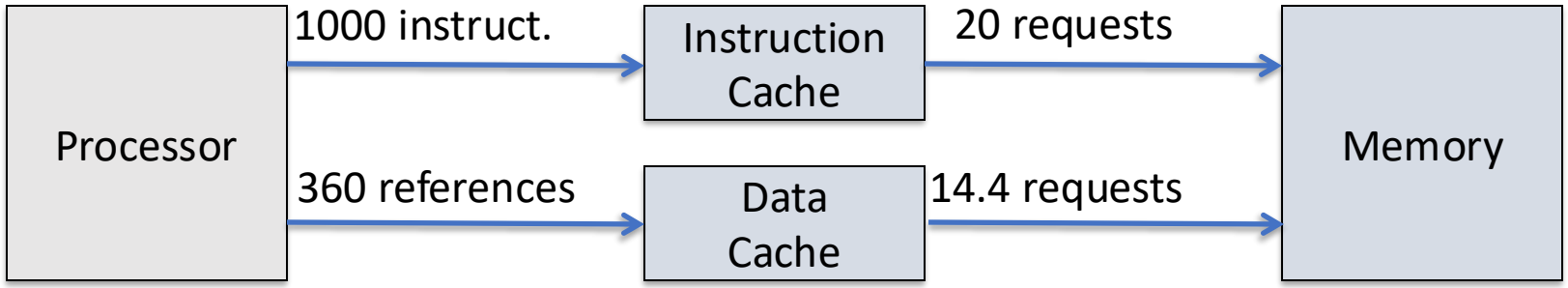

$0.04 \times 360 = 14.4$ requests

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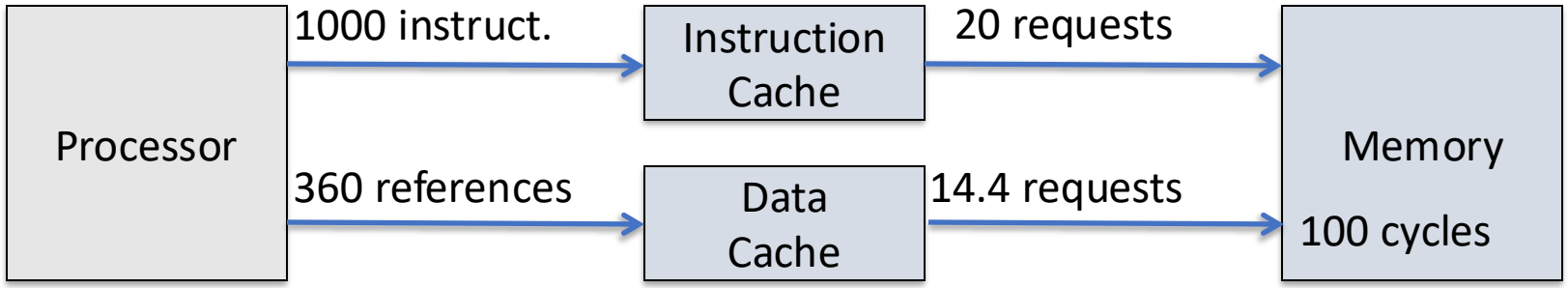

Stall Cycles = 34.4 × 100 = 3440 cycles

Without Memory Stalls: 2000 cycles

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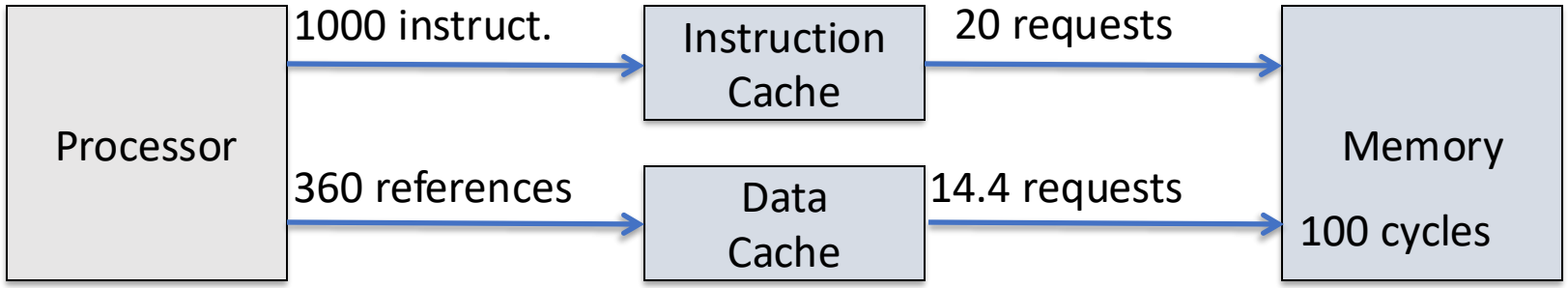
$$\frac{3440}{5440} = 63\%$$



Stall Cycles = 34.4 × 100 = 3440 cycles

Without Memory Stalls: 2000 cycles

$$\frac{\text{Real}}{\text{Ideal}} = \frac{3440 + 2000}{2000} = 2.72$$

Calculating Cache Performance (example)

What happens if the CPU is made faster without changing the memory speed?

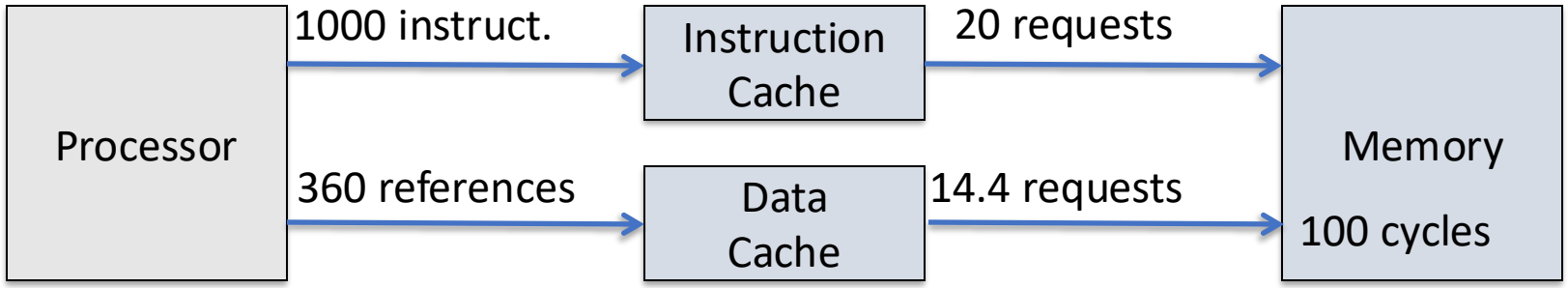
For instance, if the ideal CPI is 1 instead of 2?

Percentage of time spent on memory stalls:

$$\frac{3440}{5440} = 63\%$$

77.4%

4440



Stall Cycles = 34.4 × 100 = 3440 cycles

1000

Without Memory Stalls: 2000 cycles

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1000

4.4

1000