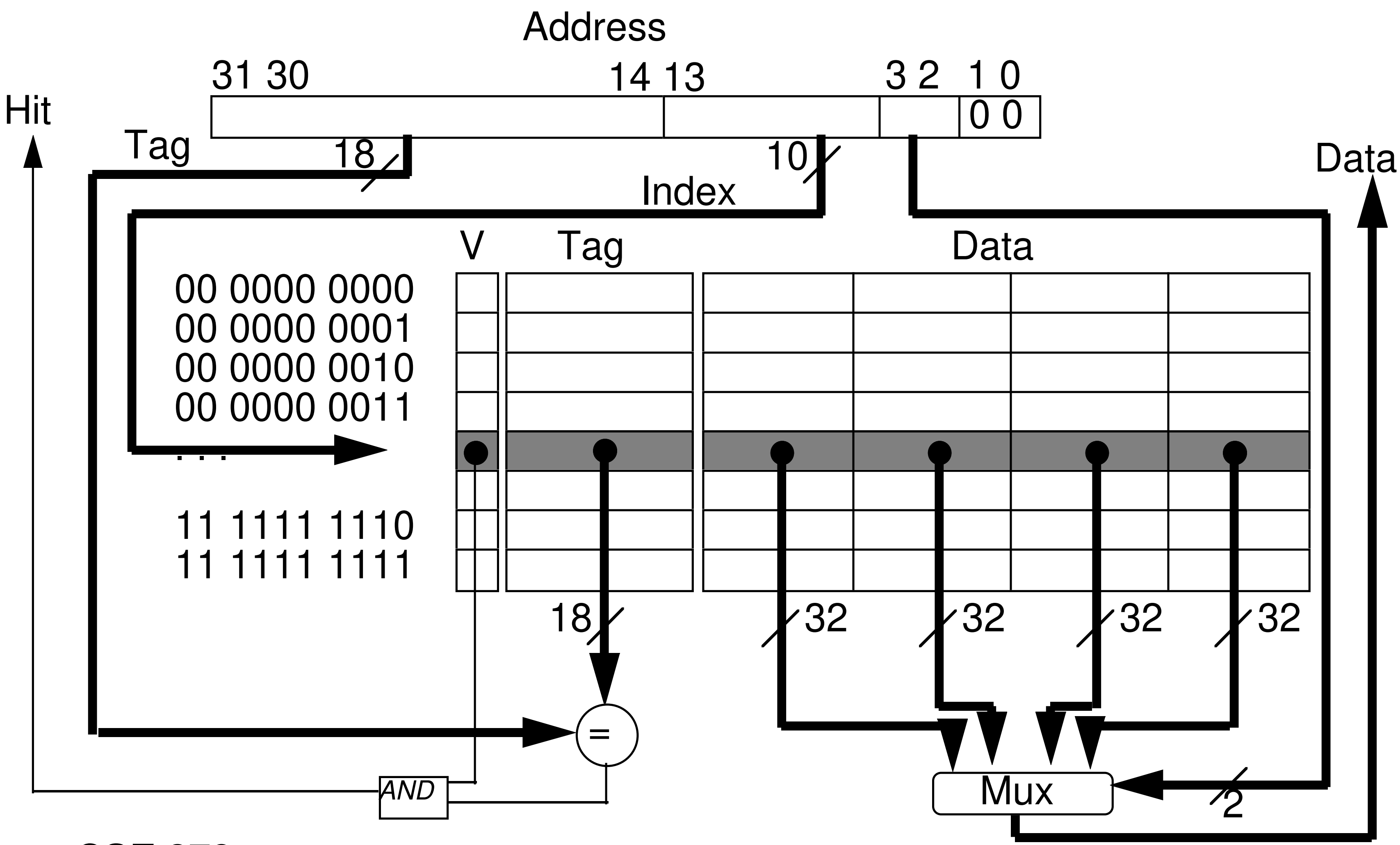
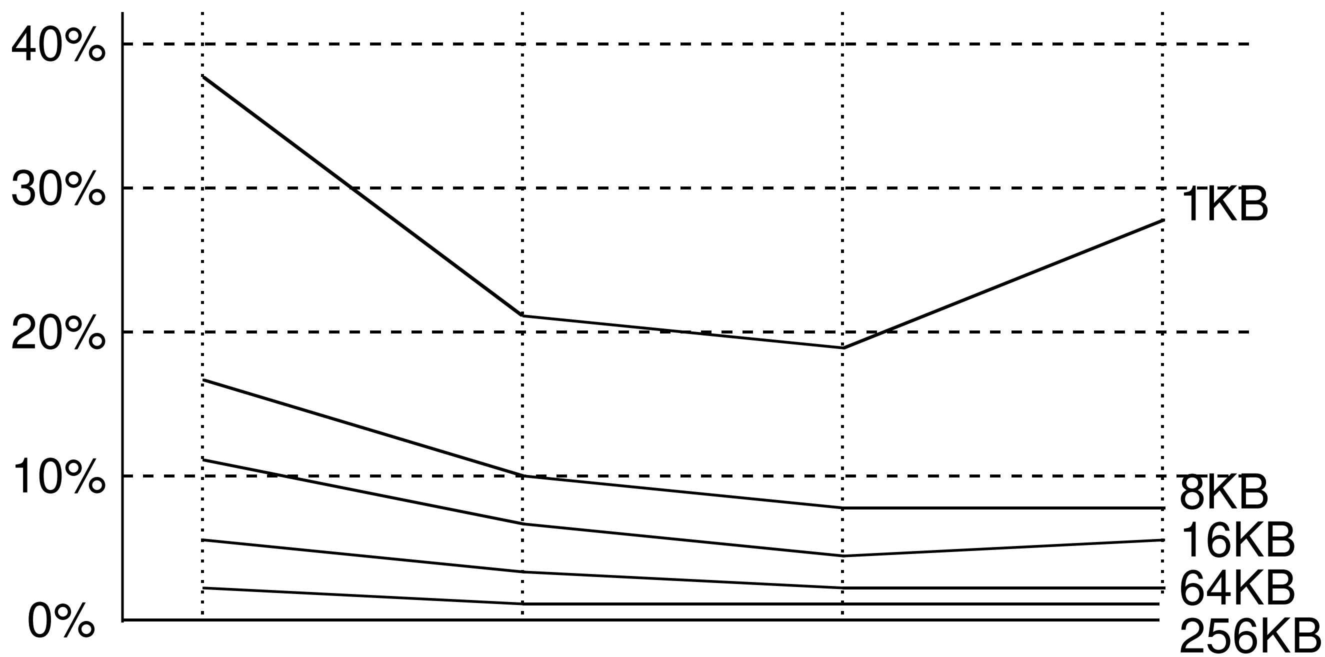
Direct Mapped (4 word block)



Miss rate vs block size



Benefits of Multiword Blocks

Increasing block size improves performance, to a point.

Larger blocks increase benefits of locality.

Larger blocks = fewer blocks for a given memory size = greater likelihood a useful block is flushed when another block is brought in.

Memory request techniques --

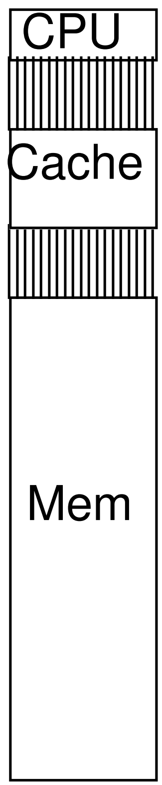
Early restart

Requested word first

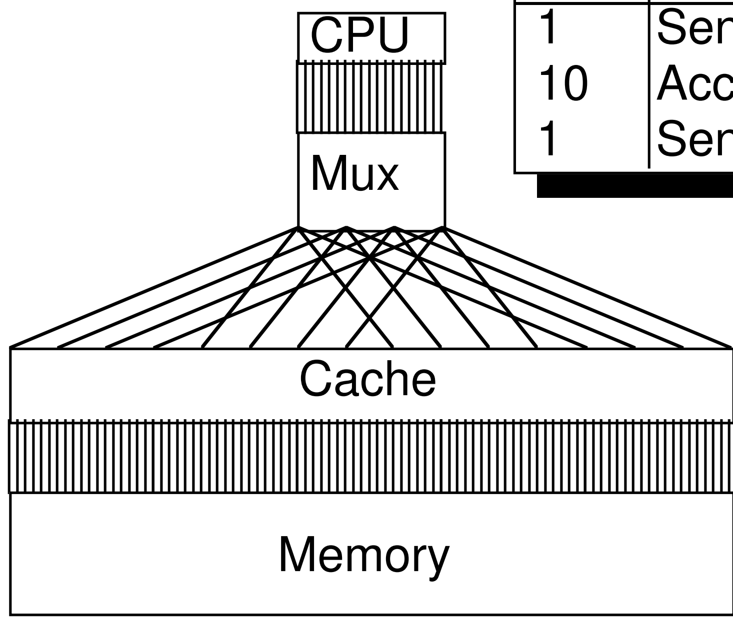
Pgm	Wd	Inst Miss	Data Miss	Effective Miss Ratio
GCC	1	6.1%	2.1%	5.4%
	4	2.0%	1.7%	1.9%
Spice	1	1.2%	1.3%	1.2%
	4	0.3%	0.6%	0.4%

Memory Organizations

(a)

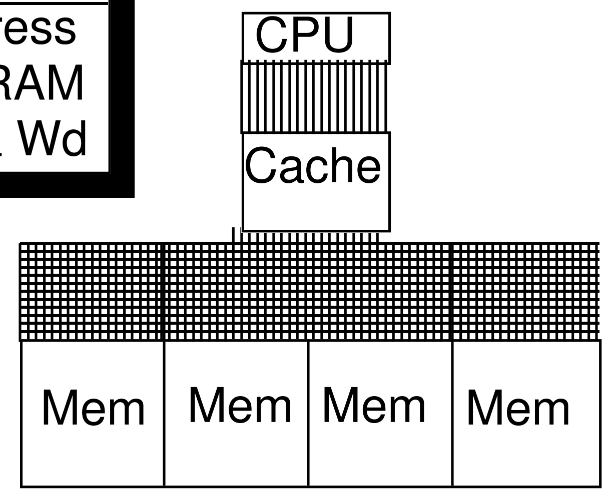


(b)



Clks	Operation
1	Send Address
10	Access DRAM
1	Send Data Wd

(c)



	(a)	(b)	(c)
Miss Penalty:	1+4x10+4x1=45	1+1x10+1=12	1+1x10+4x1=15
Bytes per Cycle:	4x4/45=0.35	4x4/12=1.33	4x4/15=1.0

Caching And Performance

(A Simple Model)

CPU time = (CPU_execution_clocks+Memory-stall_clocks) x Cycle_time
Memory-stall_clocks = Read-stall_clocks + Write-stall_clocks

Read-stall_clocks = Read/Program x Read_miss_rate x read_miss_penalty

Write-stall_clocks = (Write/Program x Write_miss_rate x write_miss penalty)+
Writebuffer-stalls

Memory-stall_clocks = Memory_accesses/Program x Miss_rate x Miss_penalty

Memory-stall_clocks = Insts/Program x Misses/Inst x Miss_penalty

Example

Data:
- 5% instruction misses,
- 10% data misses,
- CPI without stalls = 4,
- miss penalty =12.

What is the CPI including misses?

Inst_Miss_clocks = IC x 5% x 12 = 0.6x IC

Assume GCC numbers, 22% LW + 11% SW implies:

Data_Miss_clocks = IC x 33% x 10% x 12 = 0.4xIC

Memory stalls = 0.6IC + 0.4IC = 1.0IC Thus, CPI = 5 with stalls.

Caching Performance (Continued)

CPI is 25% worse due to stalls ...

Consider doubling the clock rate without changing the memory system:

Miss_cycles/instruction = 5% x 24 + 33% x (10% x 24)
= 2.0 added to CPI

How much faster is the faster machine with the 2x clock?

$$\frac{\text{Performance}_{fast}}{\text{Performance}_{slow}} \quad \frac{\text{Ex\_time}_{slow}}{\text{Ex\_time}_{fast}} \quad \frac{\text{IC x CPI x cycle}}{\text{IC x CPI x (cycle/2)}} \quad \frac{5}{6\text{x}0.5} \quad \frac{5}{3}$$

Thus, the 2x machine is actually 1.67 times faster.