Part 1: How is memory structured?

Part 1: How is memory structured?

Wordline activates a row (word) of the memory for reading/writing

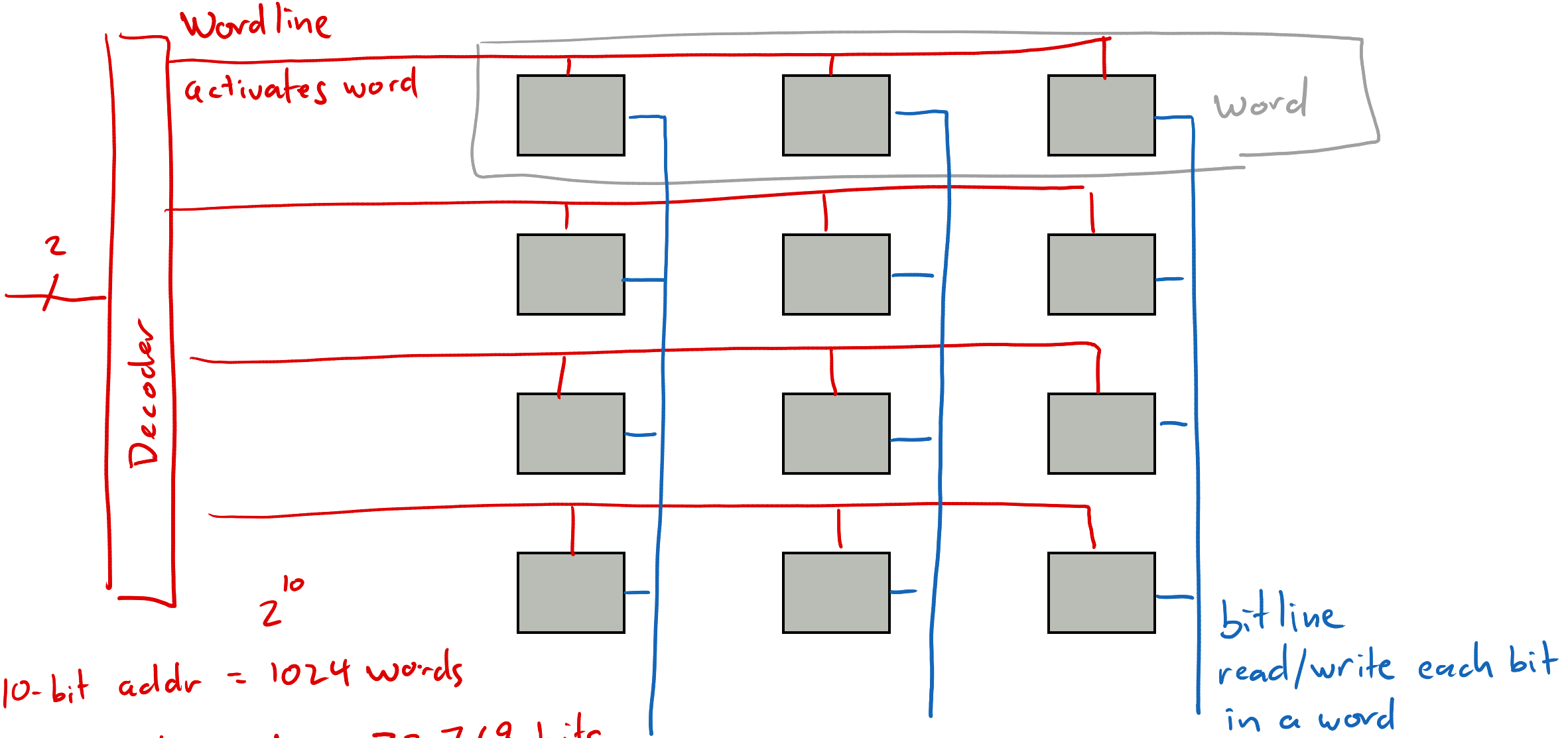
Bitline connects to a column, and reads/writes an individual bit

Address specifies which word of memory to operate on

Decoder takes the address (as a binary number) and turns on the corresponding wordline

Data bus aggregates the bitlines to carry the complete word

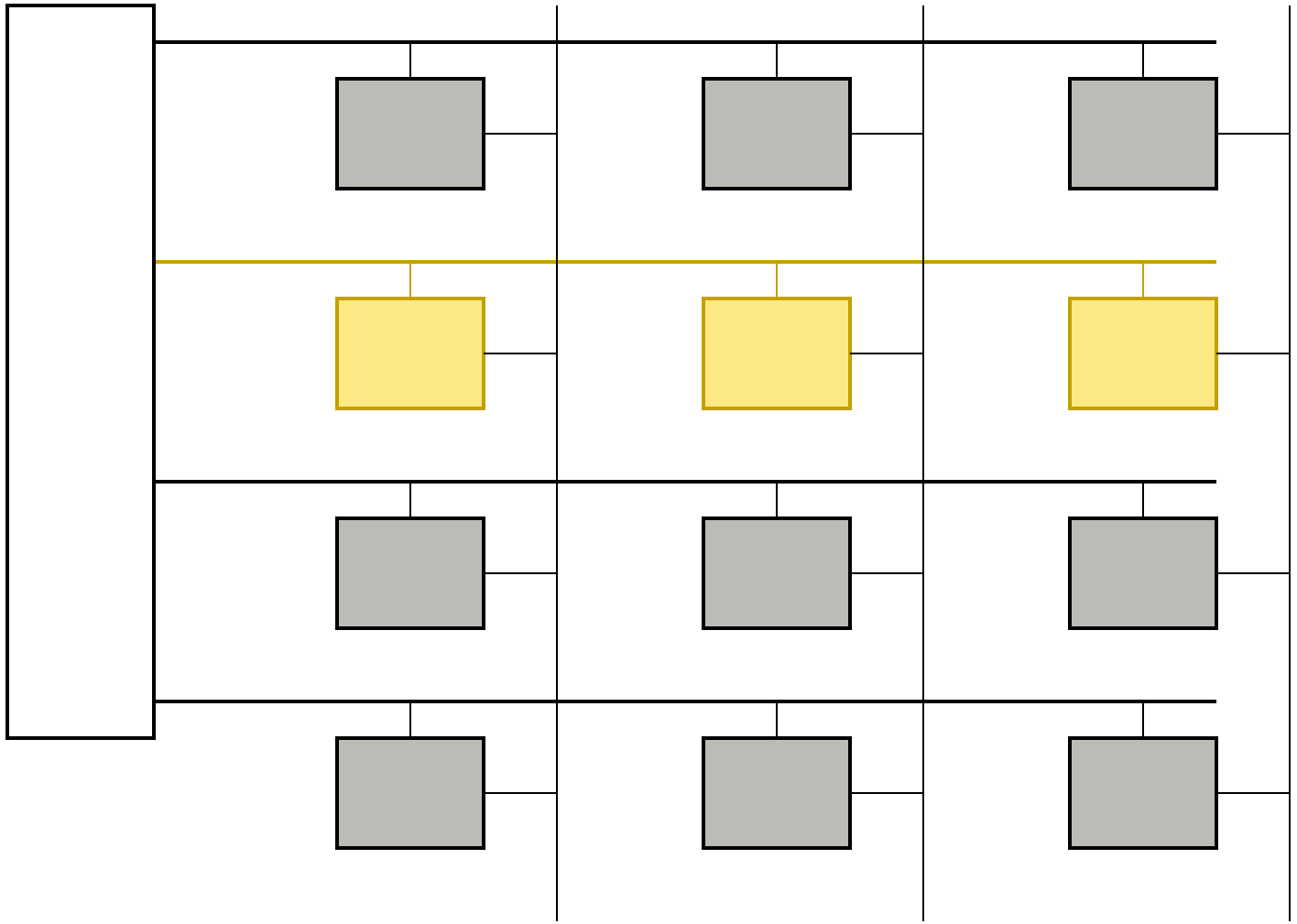
Part 1: How is memory structured?



10-bit addr = 1024 words

32-bit words 32768 bits

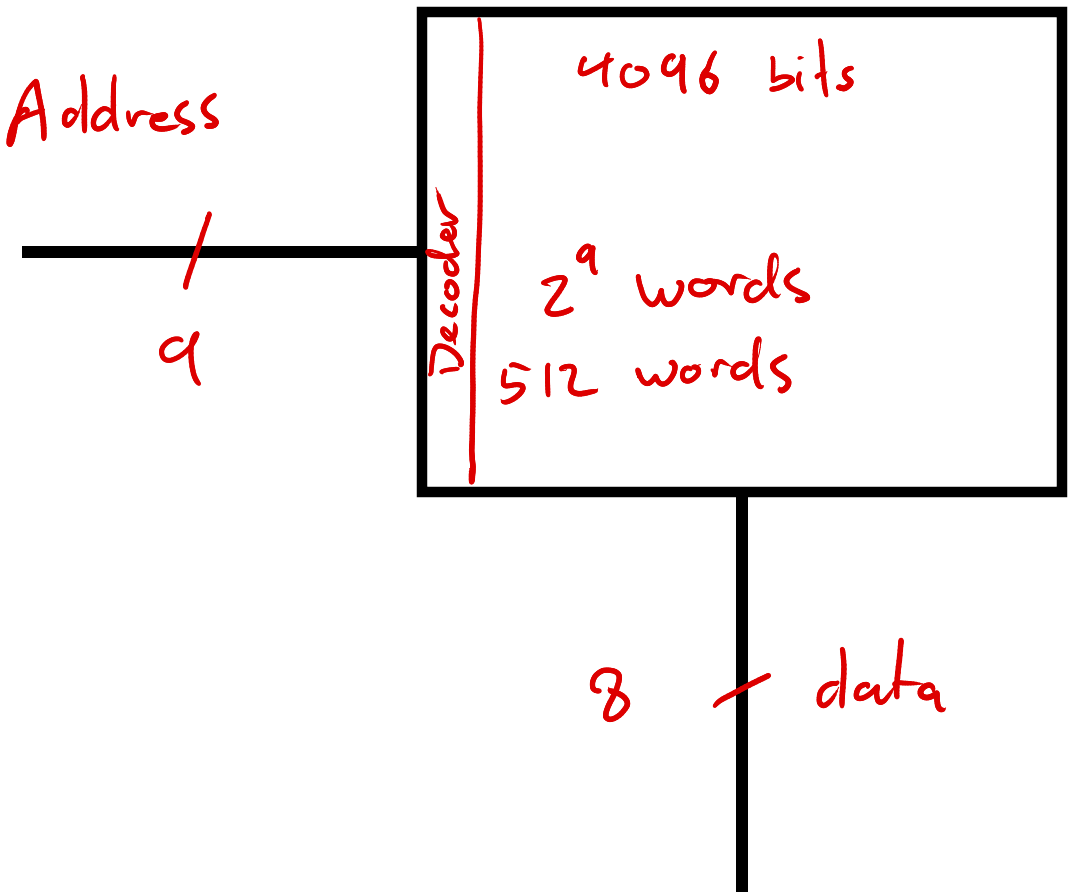
Reading / writing a word



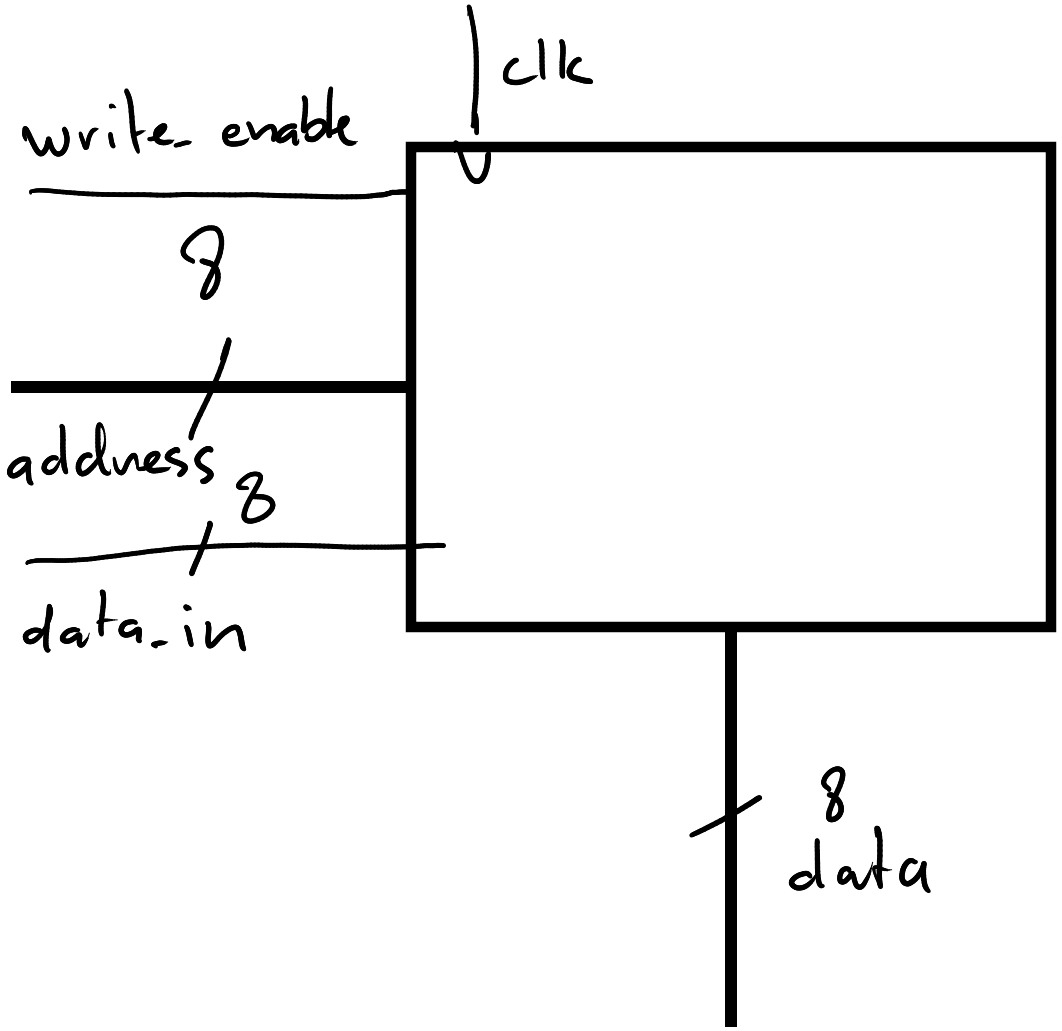
An abstracted view of (read-only) memory

FPGA has 30 4096-bit memories

2^{12}



An abstracted view of (read-write) memory



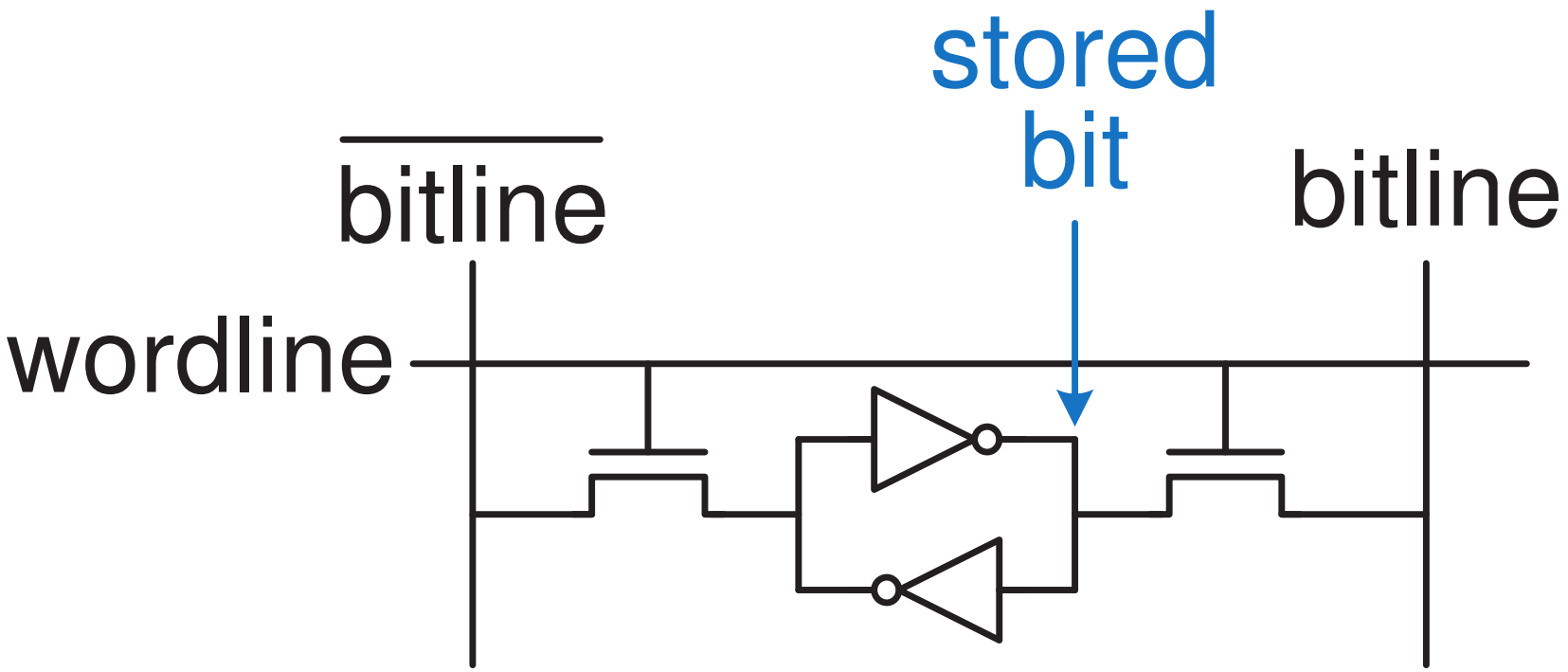
Part 2: Inside SRAM and DRAM

SRAM is "**static** random-access-memory"

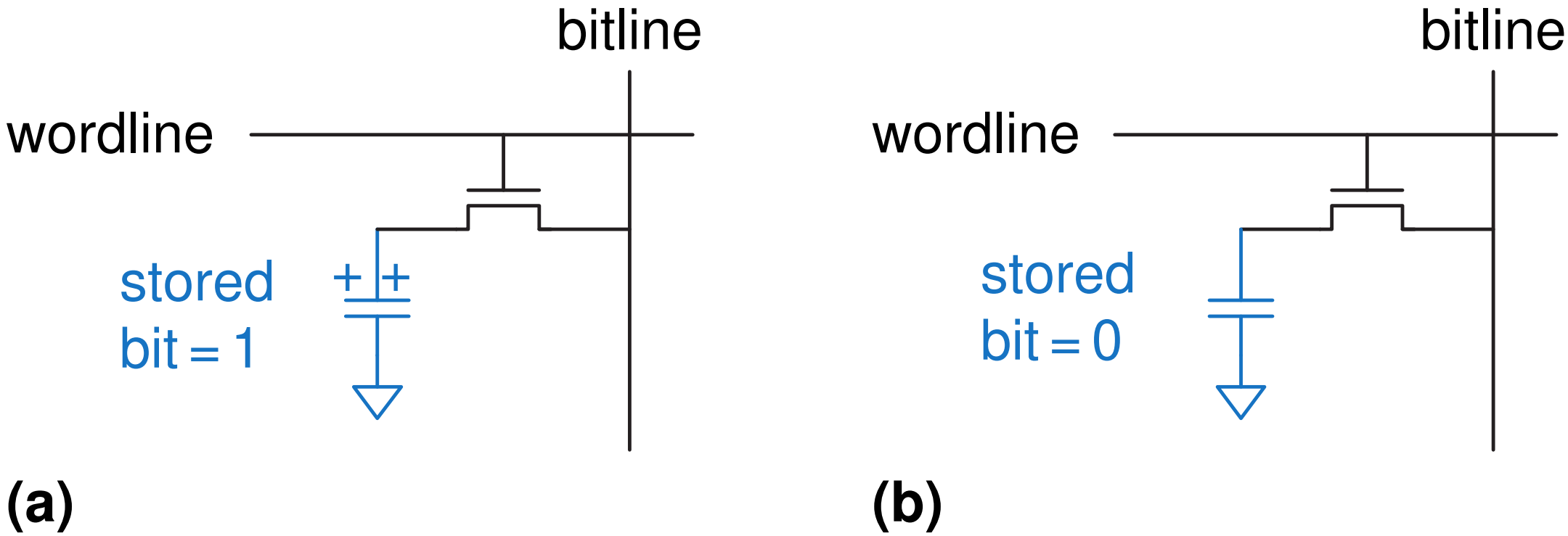
DRAM is "**dynamic** random-access-memory"

Inside SRAM

1) wordline enables transistors
2) bitlines override inverters and force a new value
3) wordline goes low again

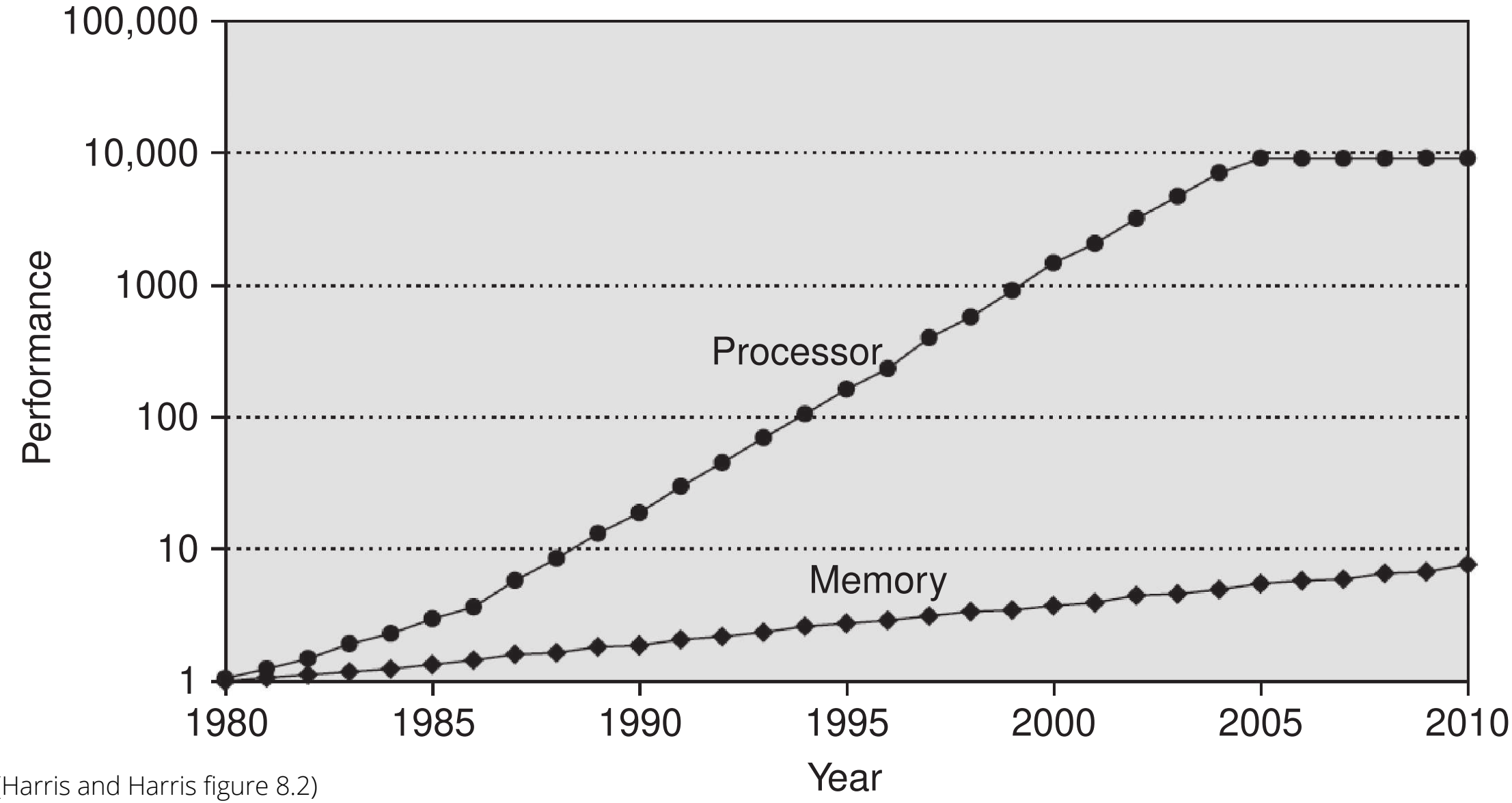


Inside DRAM


bitline
wordline
stored
bit = 1
+ +
(a)
bitline
wordline
stored
bit = 0
(b)

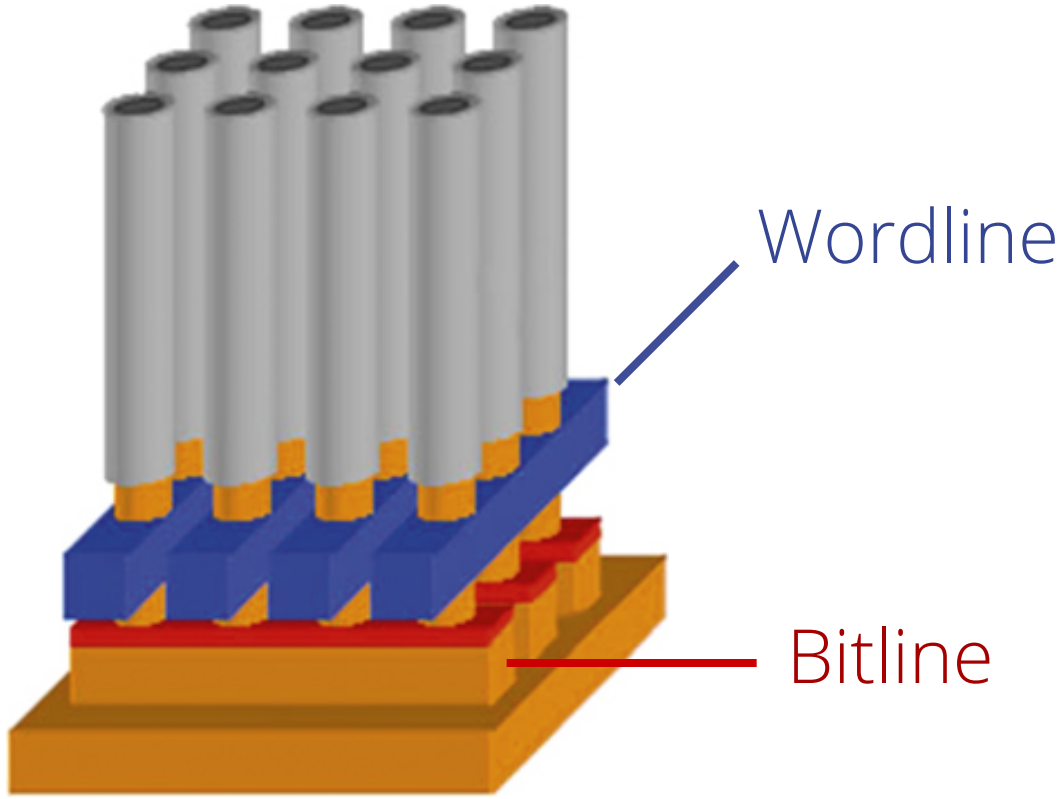
Part 3: Why do we need different kinds of memory?

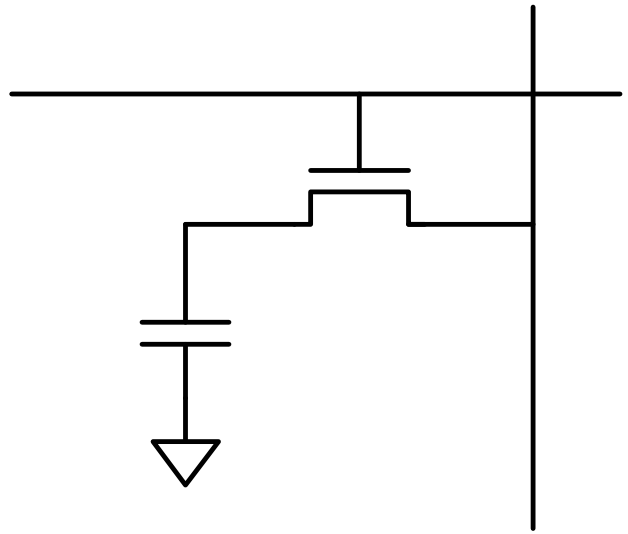
Memory (DRAM) vs CPU speeds



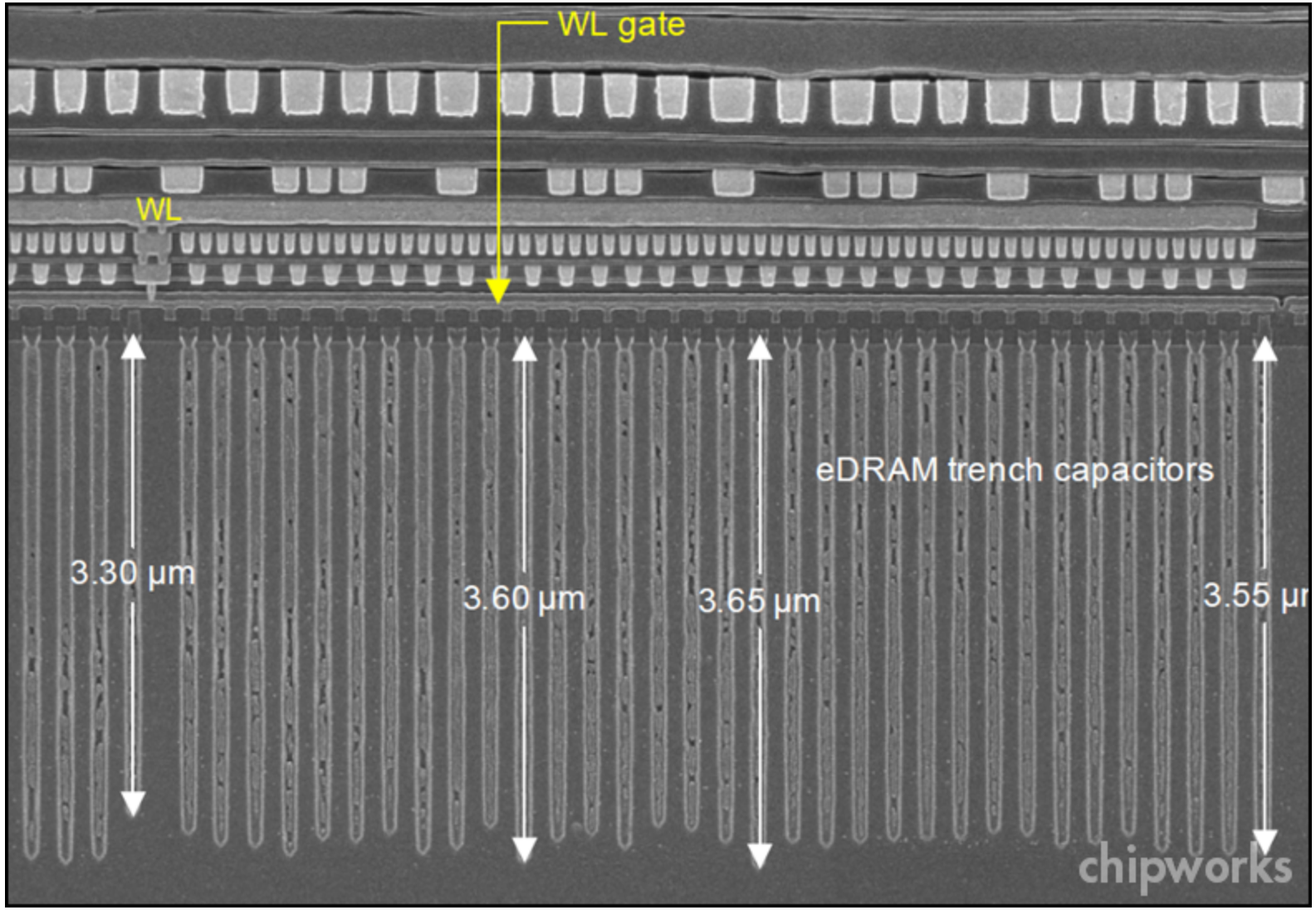
(Harris and Harris figure 8.2)

DRAM cell





DRAM cross section

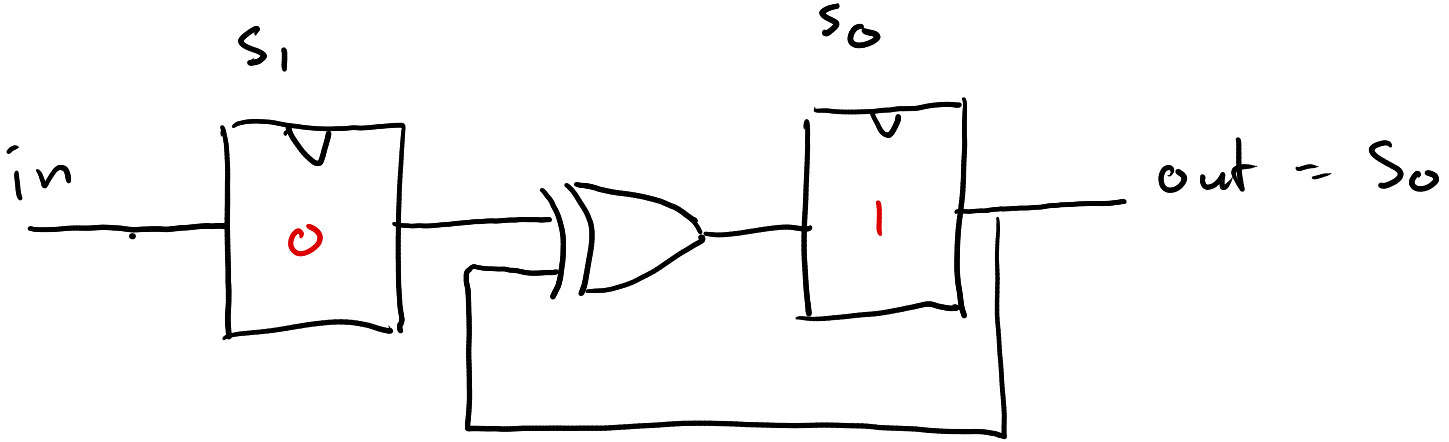


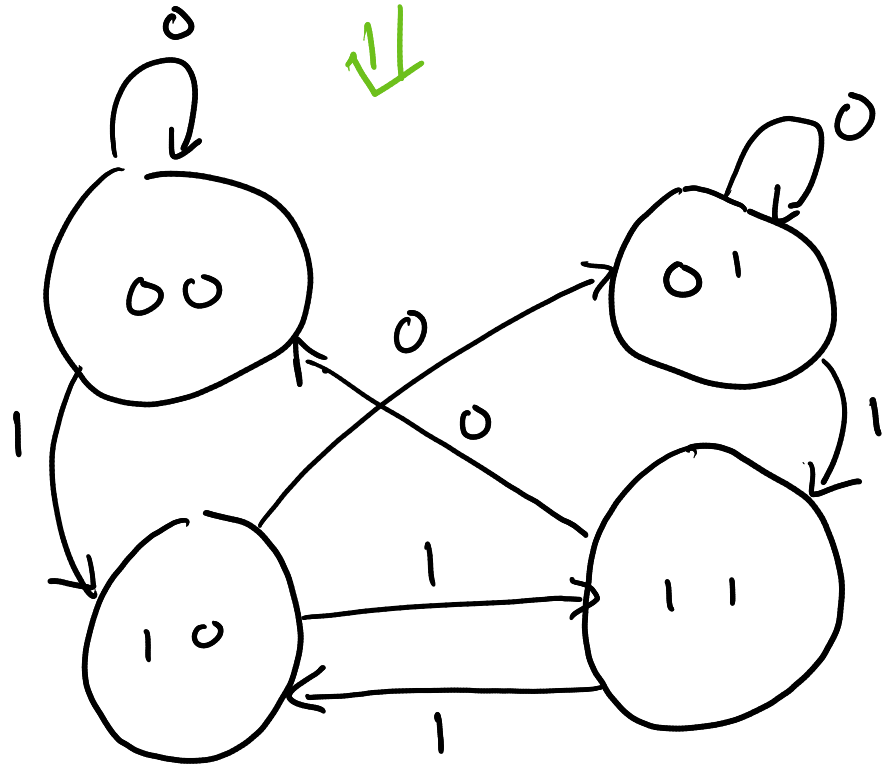
(image from chipworks http://chipworksrealchips.blogspot.com/2014/02/intels-e-dram-shows-up-in-wild.html)

Comparing memory technologies

	SRAM				
	Register file	Cache	DRAM	Flash	Hard drive Spinning disk
Cost/bit	$$$$	$$$	$ $	$ $	$
Speed	1 cycle	< 10 cycles	>100	< 1 ms	10 ms +
Non-volatile					
Typical size	64 bit x 32 reg	1MB - 8MB	8GB - 32 GB	100s GB	1 TB +

Tape drives?!





$S_1 = in$

S_0

in \ S_1 S_0	00	01	11	10
0	1	0	1	
1	0	1	0	

$S_1 \oplus S_0$

S_1	S_0	in
0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

S_1	S_0
0	0
1	0
0	1
1	1
0	1
1	1
0	0
1	0

Memory in the FPGA

Just like a flip-flop: describe the behavior you want, and Radiant will "infer" the RAM/ROM for you.

For next time

1. Continue with lab 6

2. Look for CATME survey