

# Principles of Computer Architecture

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## Chapter 8: Input and Output

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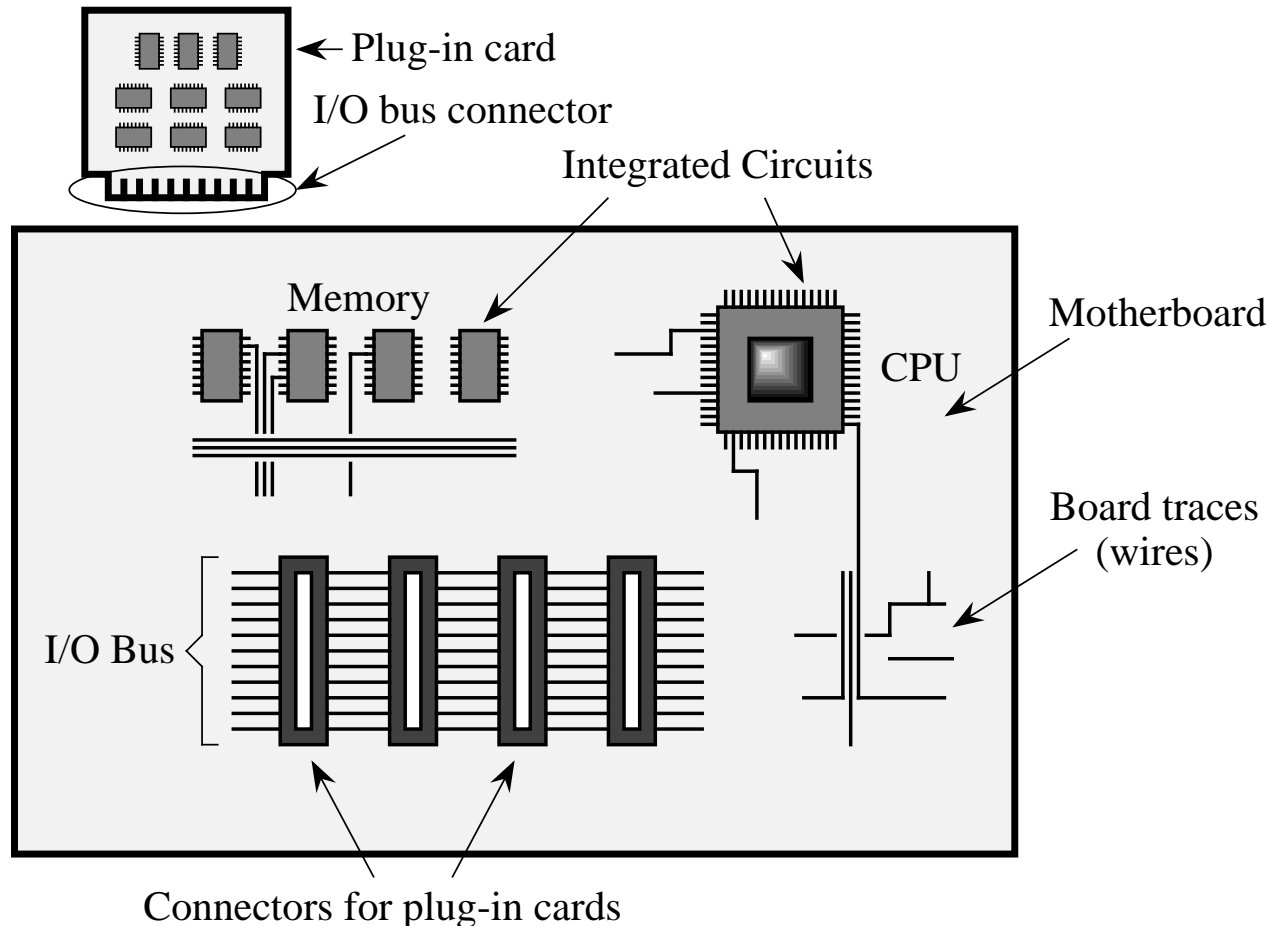
**8.5 Mass Storage**

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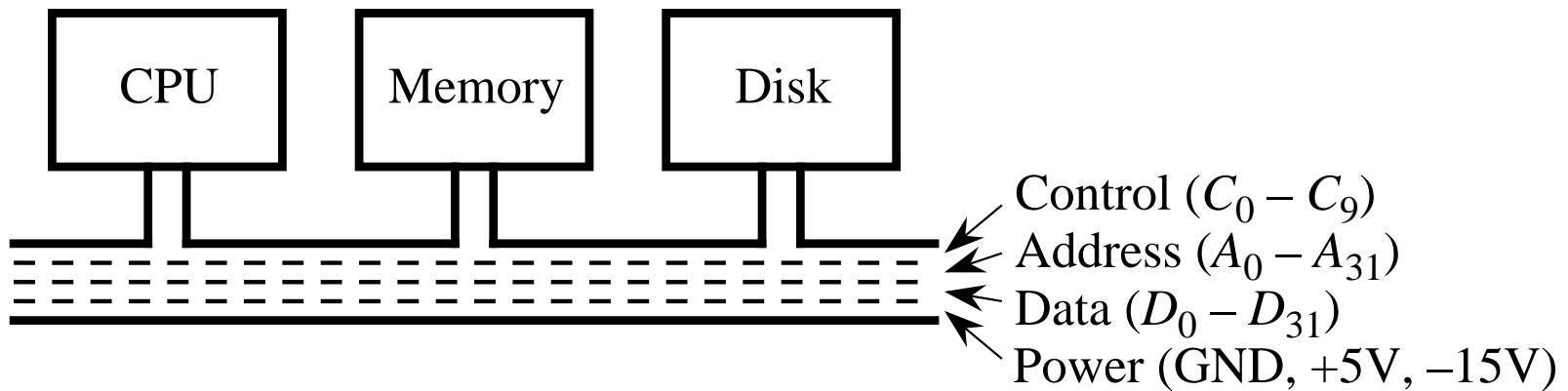
**8.7 Output Devices**

# Simple Bus Architecture

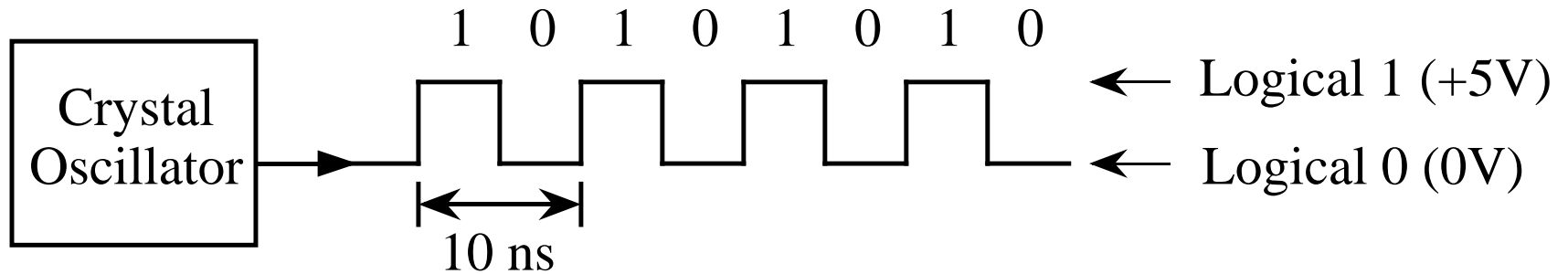
- A simplified motherboard of a personal computer (top view):



# Simplified Illustration of a Bus

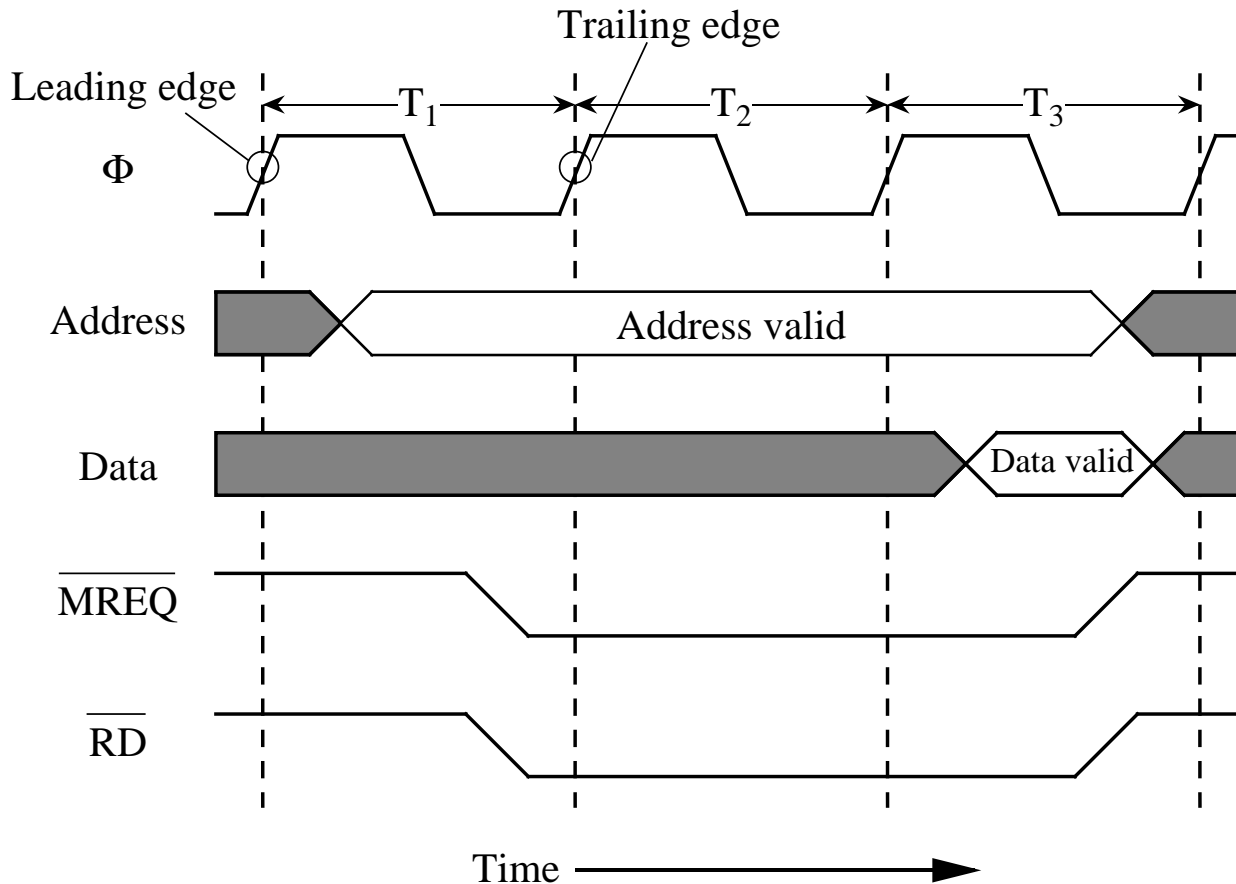


# 100 MHz Bus Clock



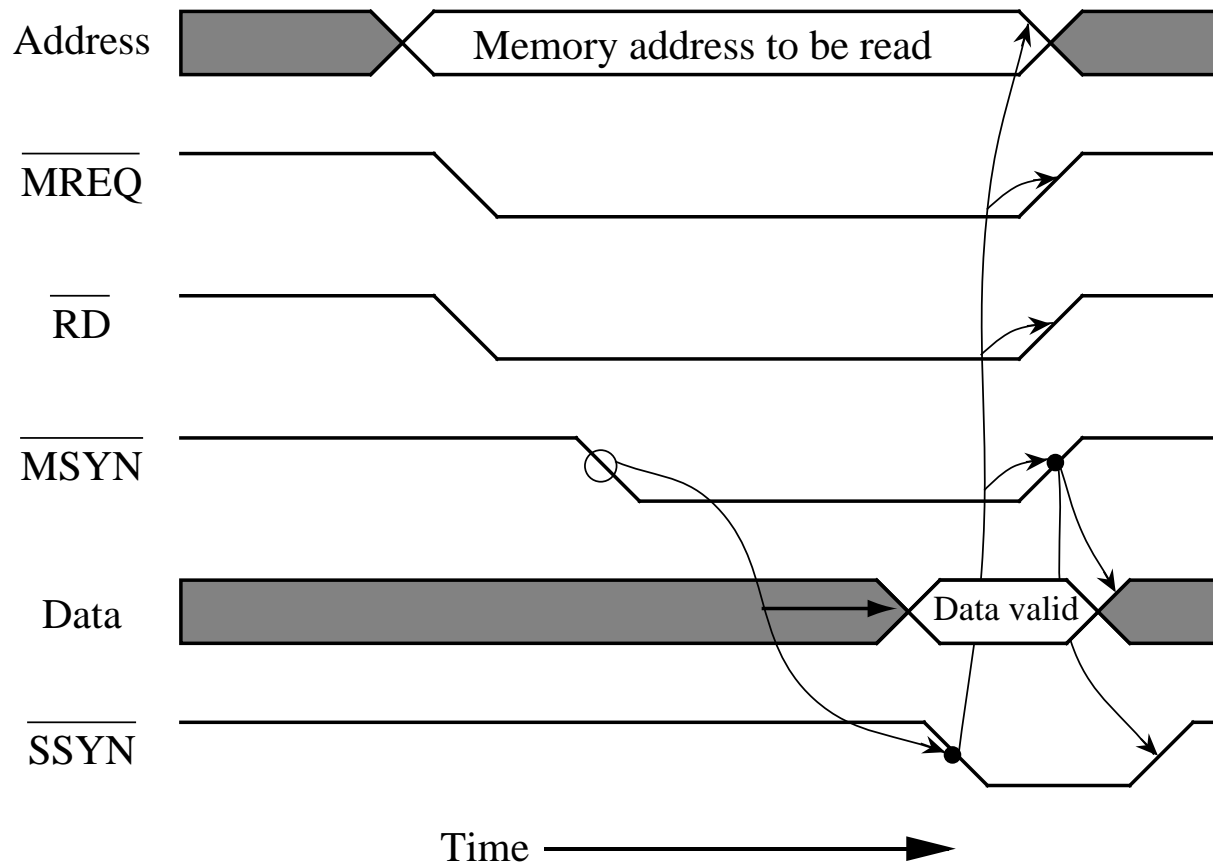
# The Synchronous Bus

- Timing diagram for a synchronous memory read (adapted from [Tanenbaum, 1999]).



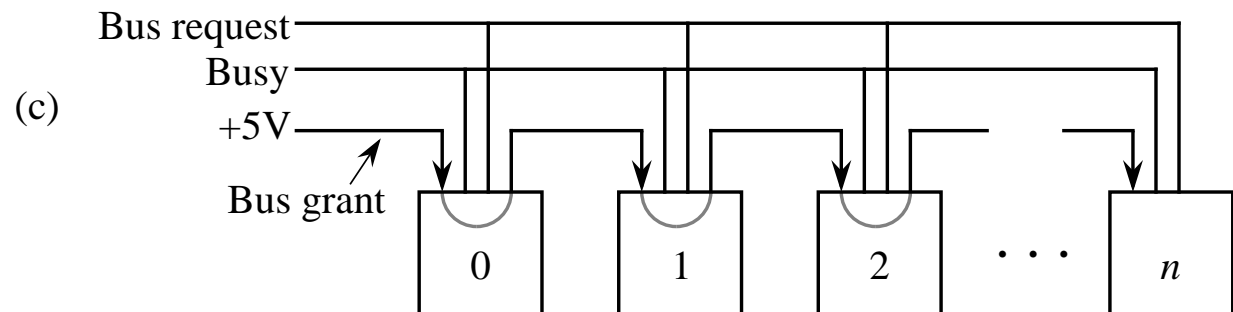
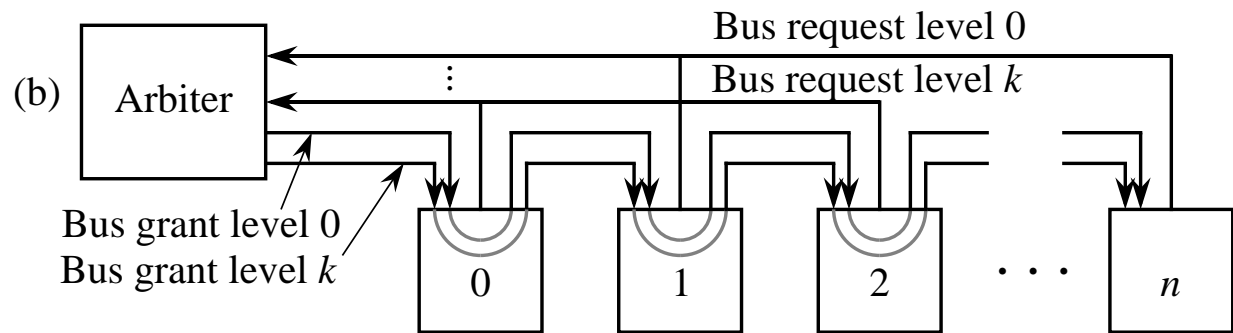
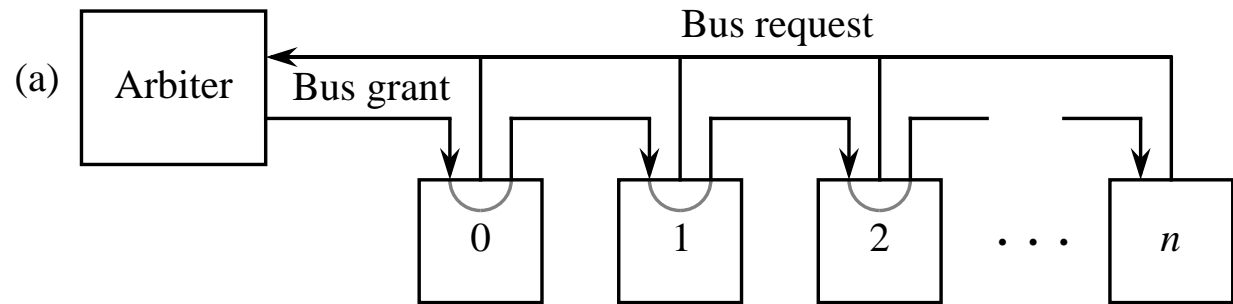
# The Asynchronous Bus

- Timing diagram for asynchronous memory read (adapted from [Tanenbaum, 1999]).



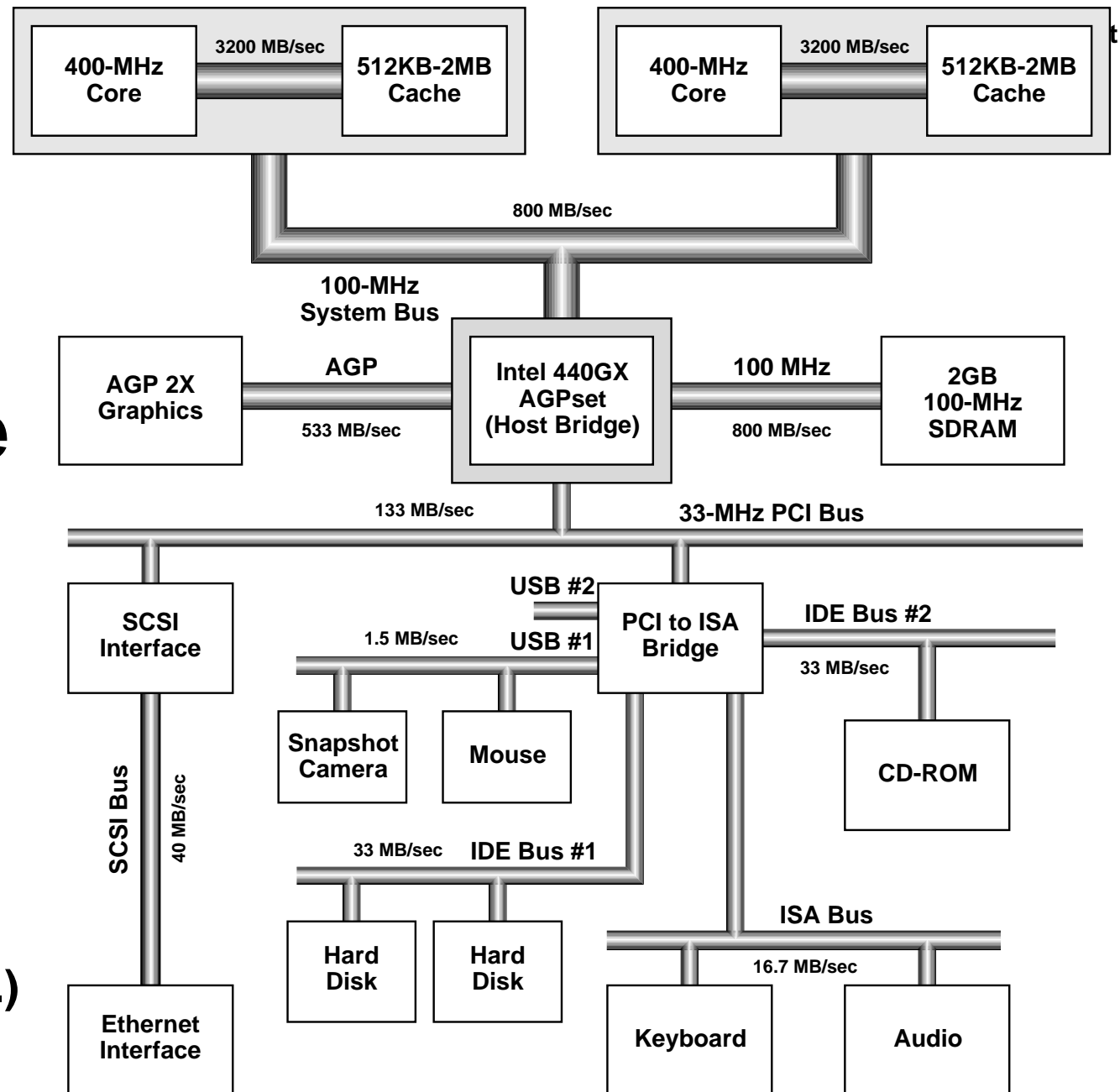
# Bus Arbitration

- (a) Simple centralized bus arbitration; (b) centralized arbitration with priority levels; (c) decentralized bus arbitration. (Adapted from [Tanenbaum, 1999]).



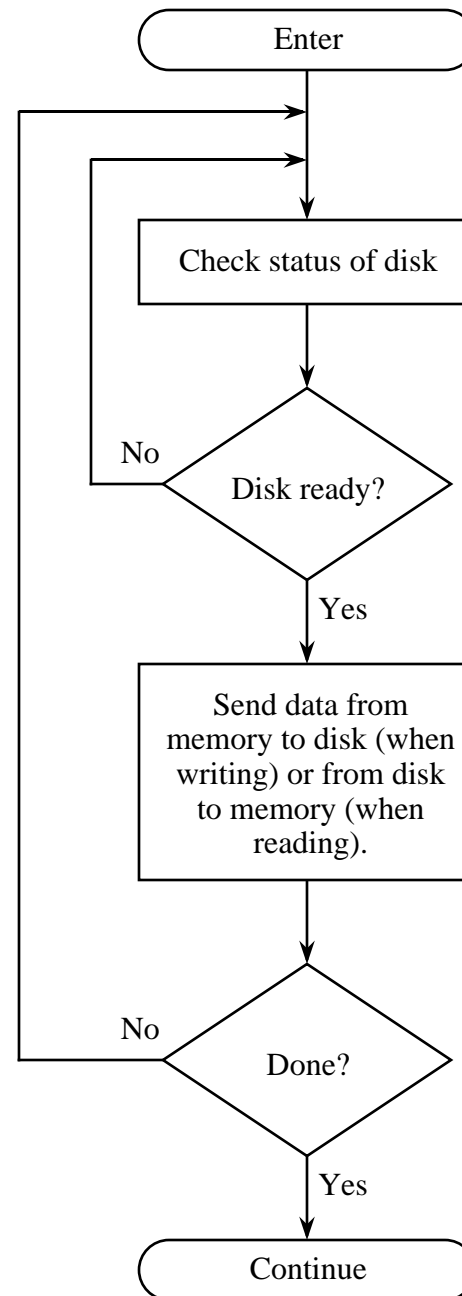


# Bridge Based Bus Architecture

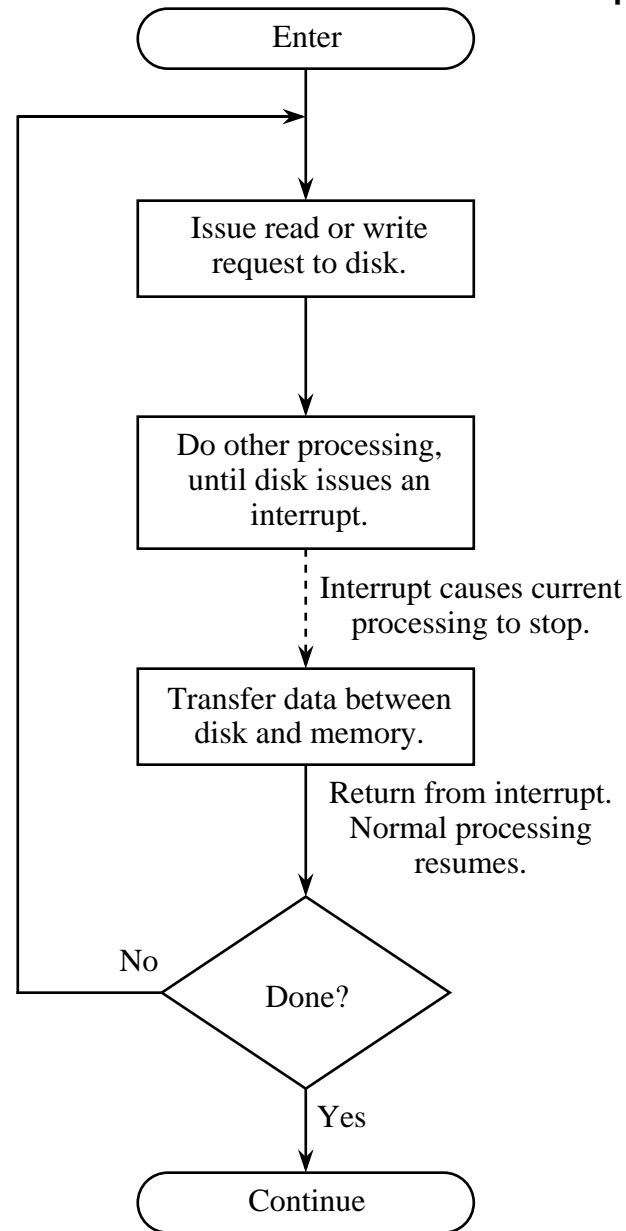


- Bridging with dual Pentium II Xeon processors on Slot 2.
- (Source: <http://www.intel.com>.)

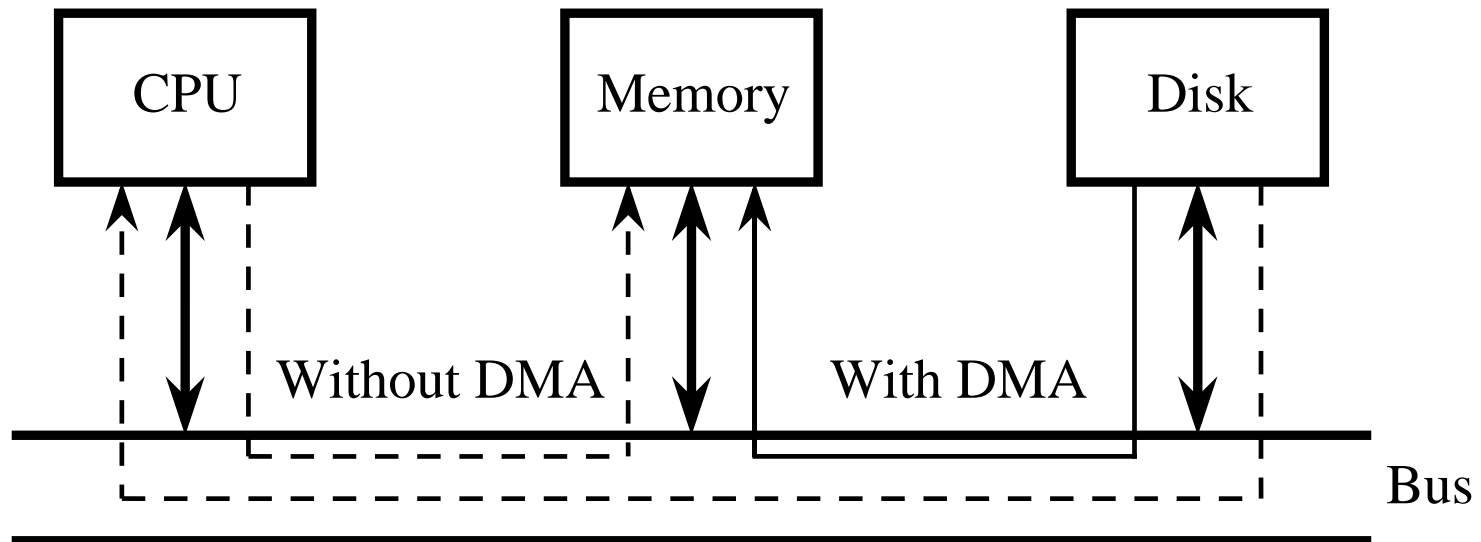
# Programmed I/O Flowchart for a Disk Transfer



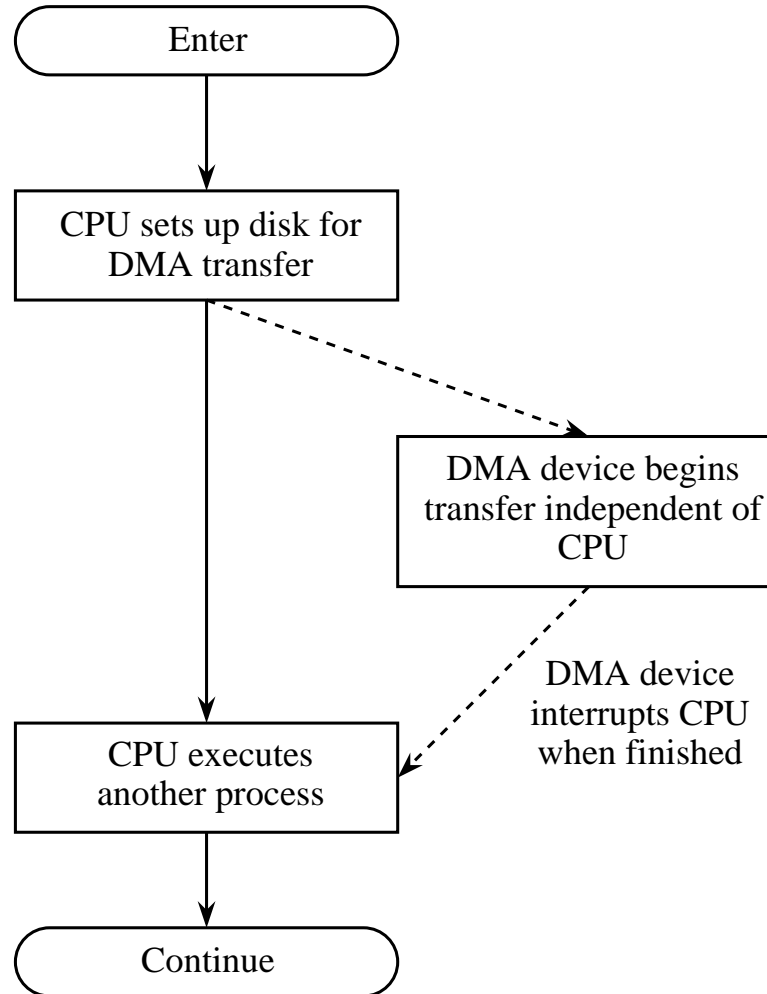
# Interrupt Driven I/O Flowchart for a Disk Transfer



# DMA Transfer from Disk to Memory Bypasses the CPU



# DMA Flowchart for a Disk Transfer



# Intel Memory and I/O Address Spaces

Address  
FFFFFFFF

Memory  
Space

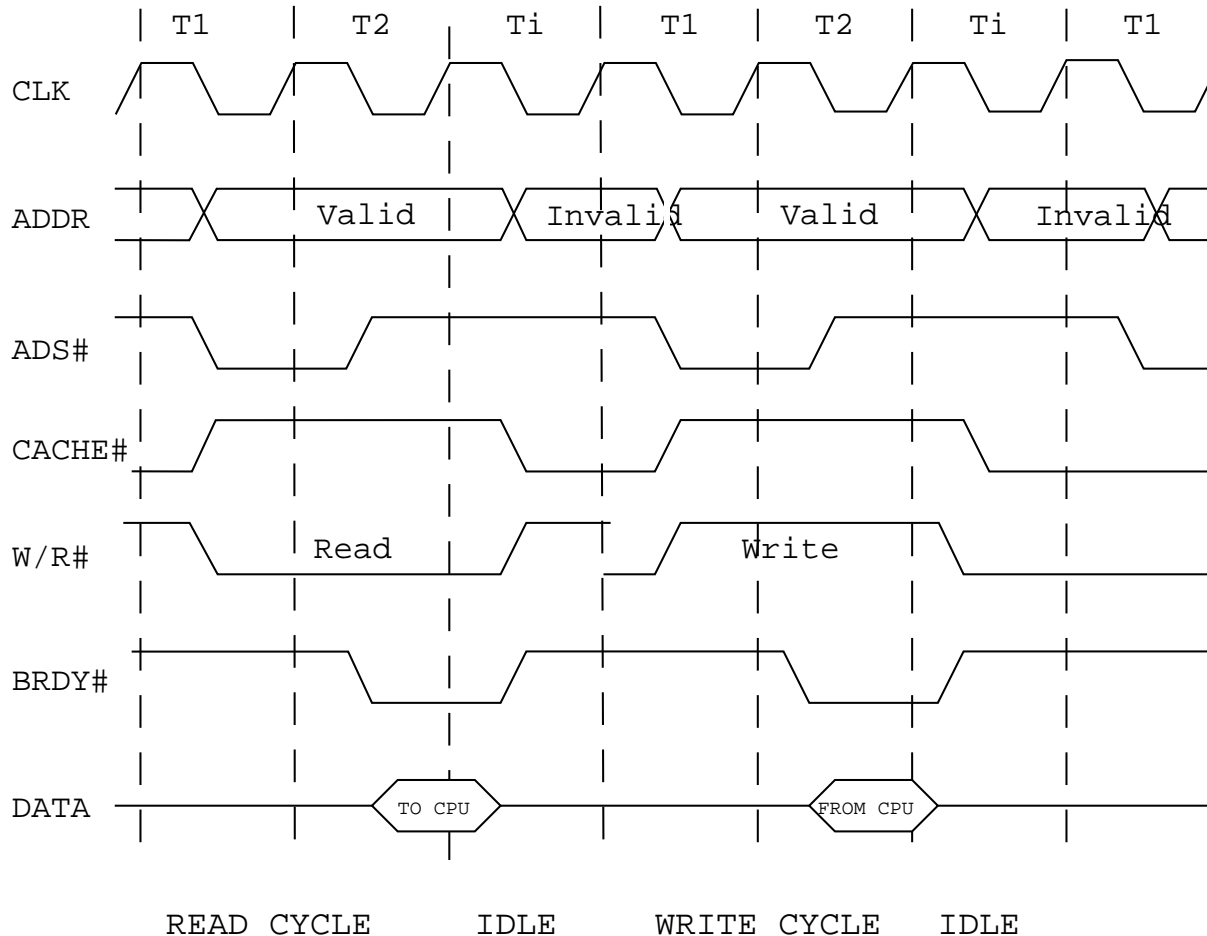
00000000

Address  
FFFF

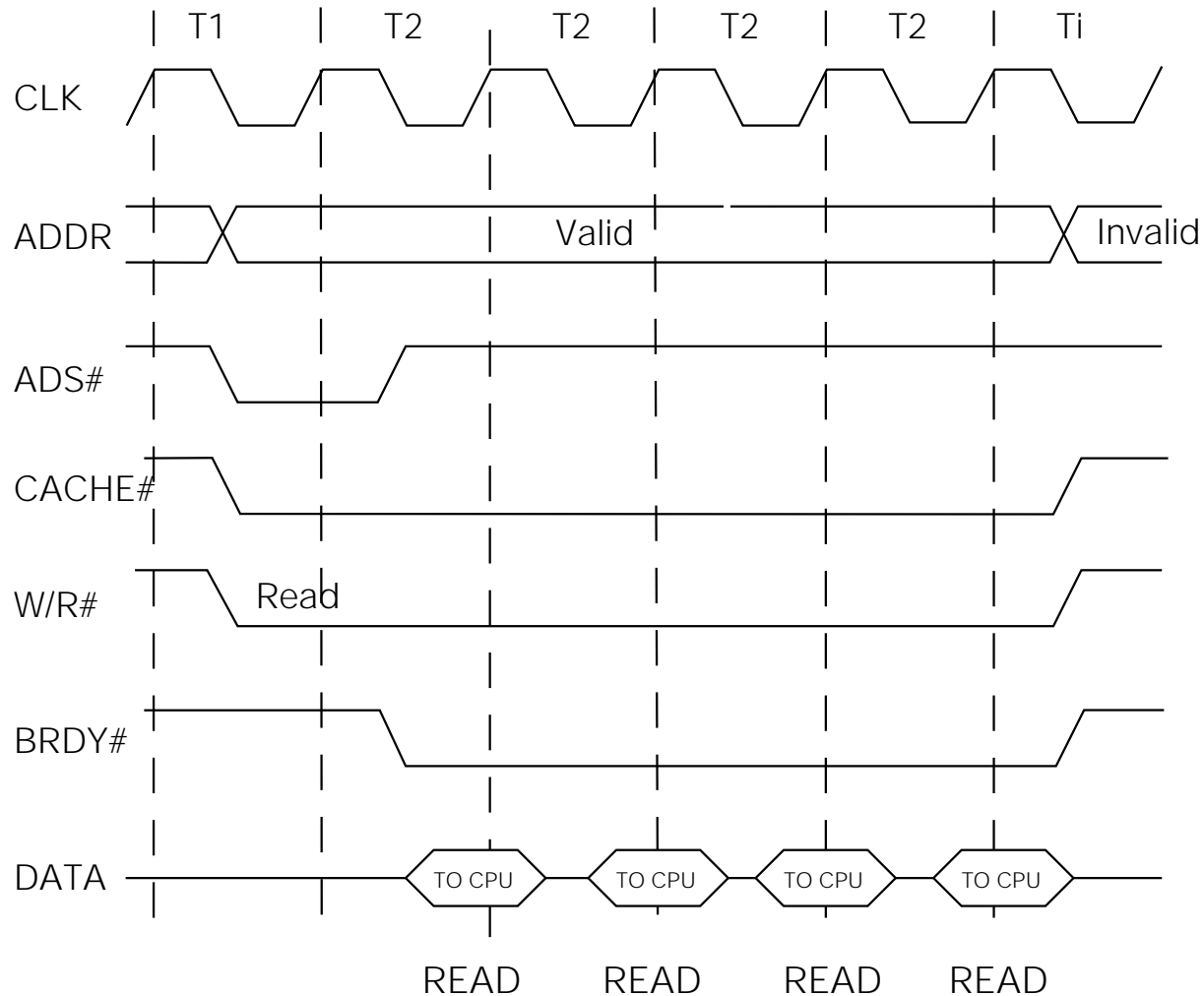
I/O  
Space

0000

# Standard Intel Pentium Read and Write Bus Cycles

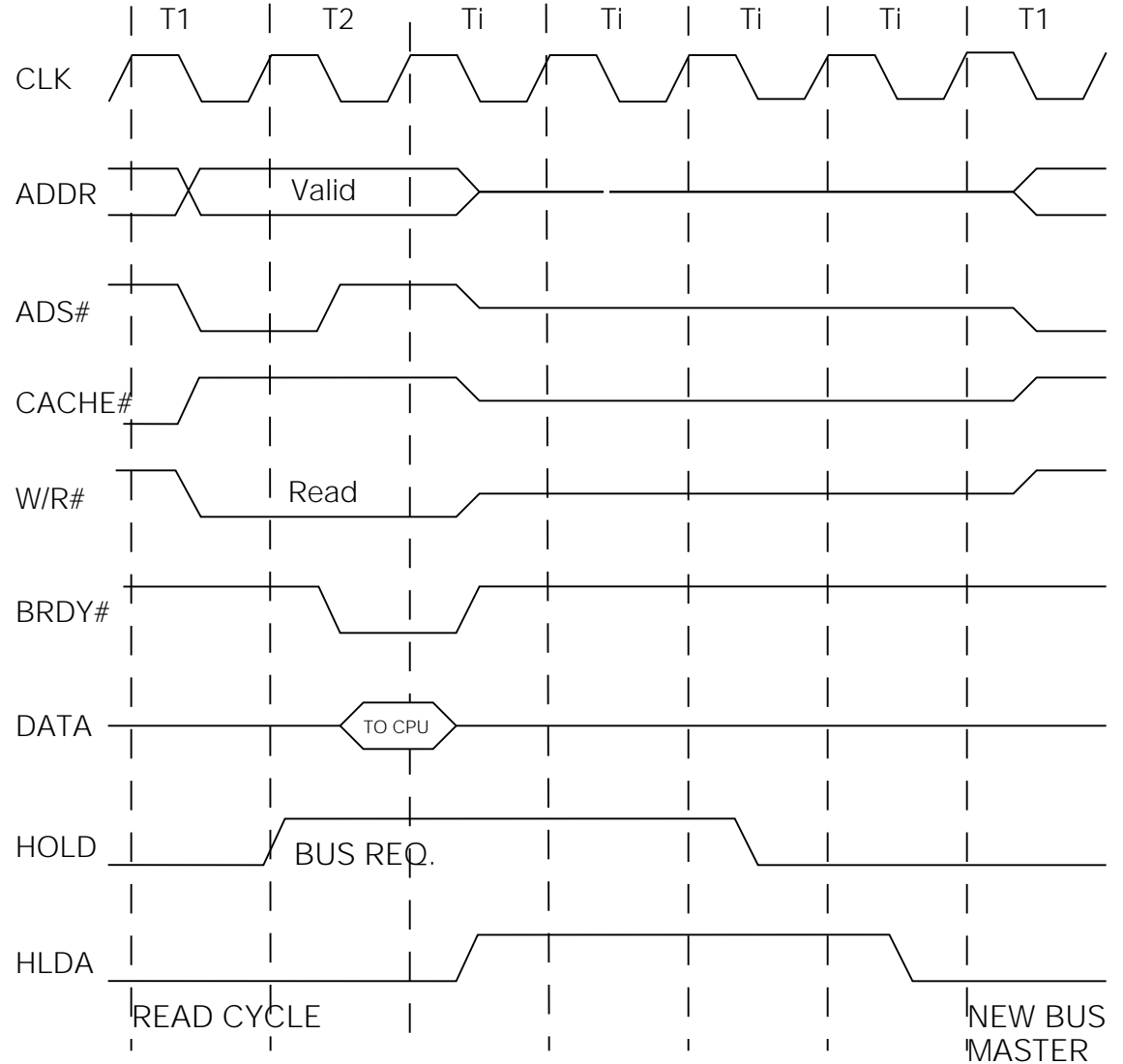


# Intel Pentium Burst Read Bus Cycle

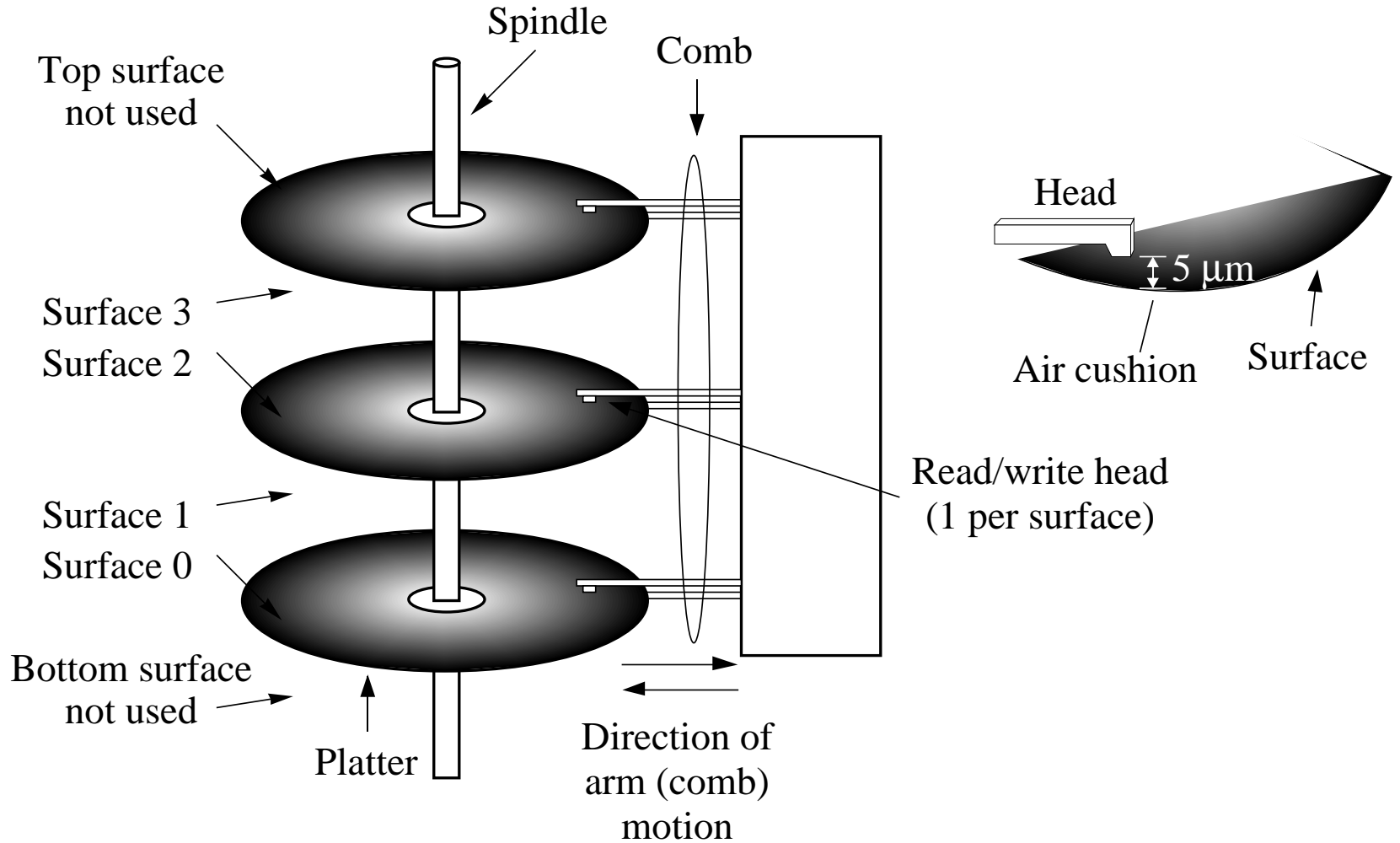




# Intel Pentium Hold-Hold Acknowledge Bus Cycle

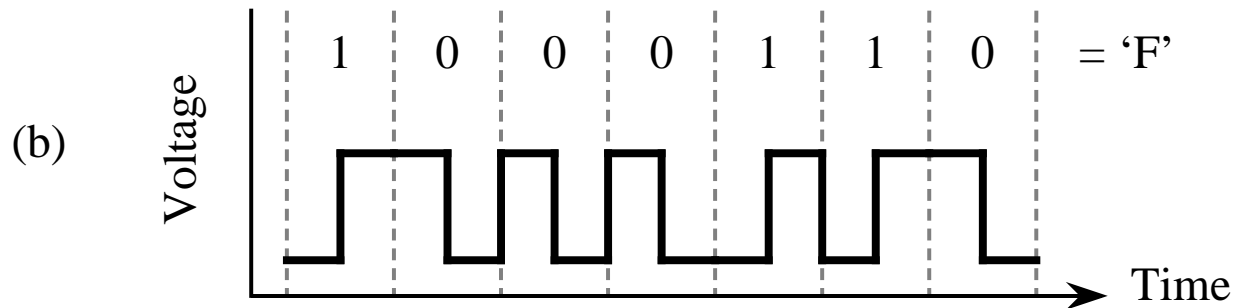
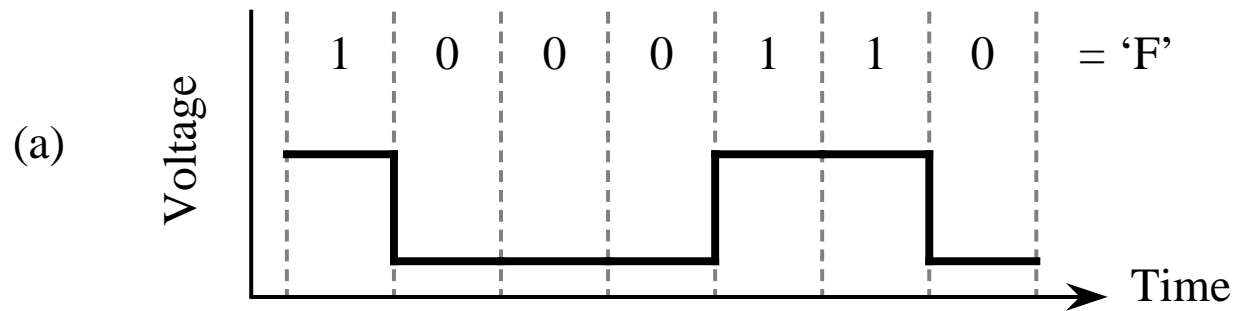


# A Magnetic Disk with Three Platters

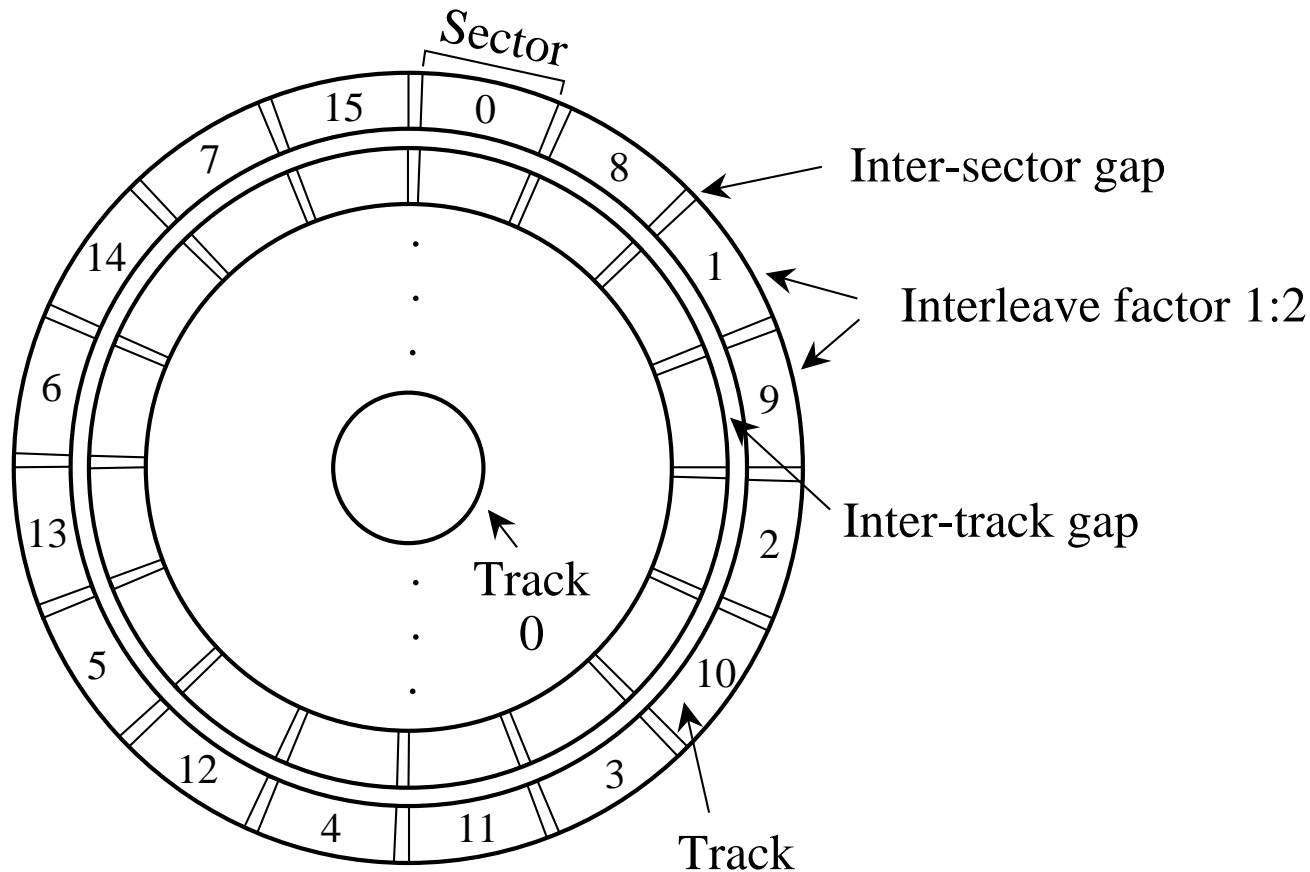


# Manchester Encoding

- (a) Straight amplitude (NRZ) encoding of ASCII 'F'; (b) Manchester encoding of ASCII 'F'.



# Organization of a Disk Platter with a 1:2 Interleave Factor



# Master Control Block

Preamble {  
 No. surfaces on disk = 4  
 No. tracks/surface = 814  
 No. sectors/track = 32  
 No. bytes/sector = 512  
 Interleave factor = 1:3

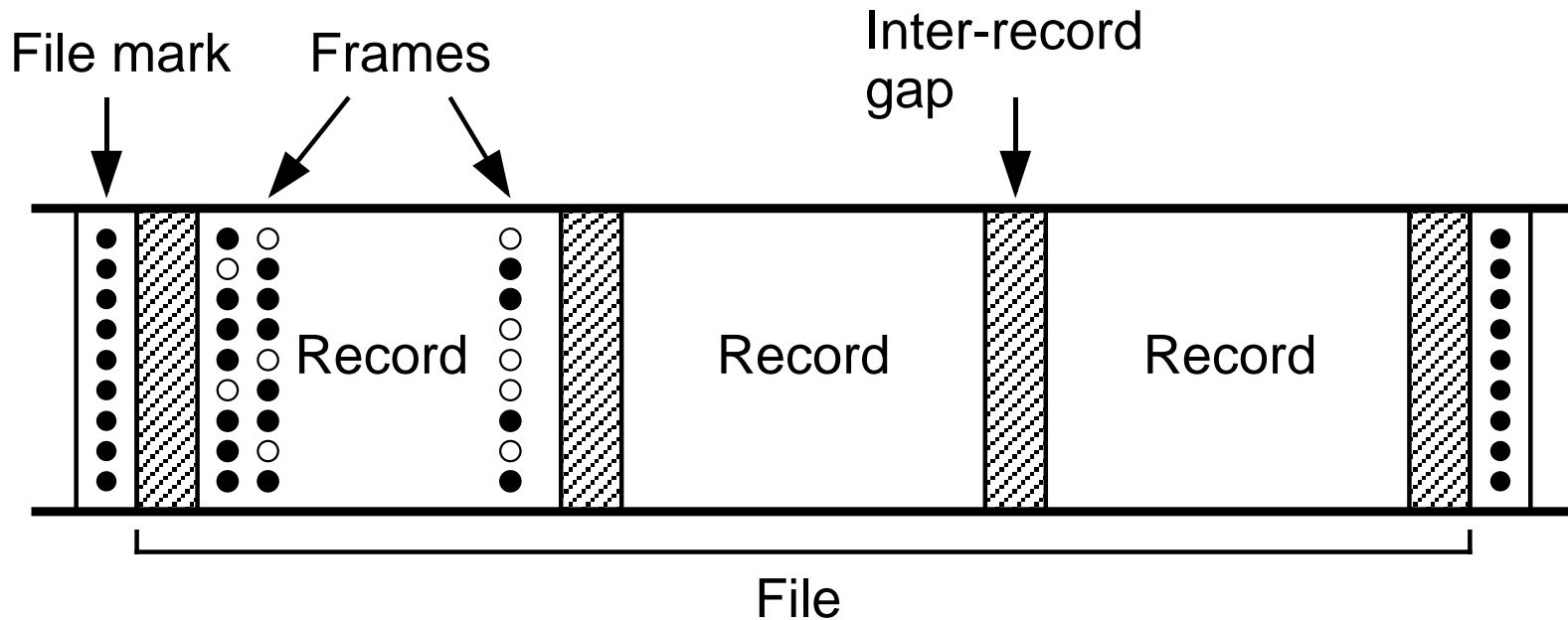
## Starting sector, or sector list

	Filename	Starting sector, or sector list			Creation Date	Last Modified	Owner	Protec-tions
		Surface	Track	Sector				
Files {	xyz.p	1	10	5	11/14/93 10:30:57	11/14/93 19:30:57	16	RWX by Owner
		1	12	7				
		2	23	4				
Files {	ab.c	1	10	8	8/18/93 16:03:12	1/21/94 14:45:03	20	RX - All W-Owner
		3	95	2				
		2	12	0				
			:					
Free blocks {		1	1	0				
		1	1	1				
		1	2	5				
			:					
Bad blocks {		1	1	3				
		2	5	7				
			:					

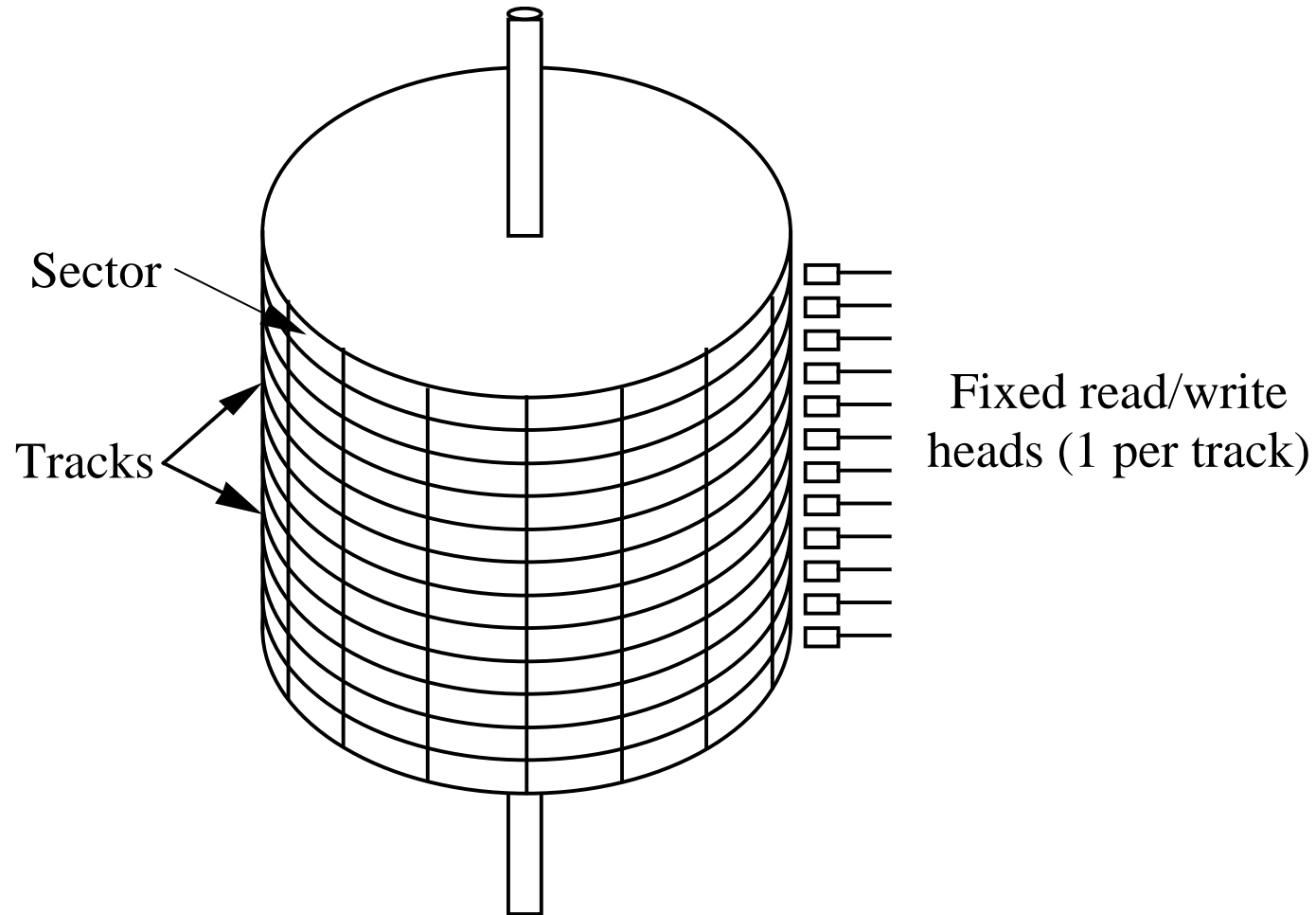
R = Read  
 W = Write  
 X = Execute

# Magnetic Tape

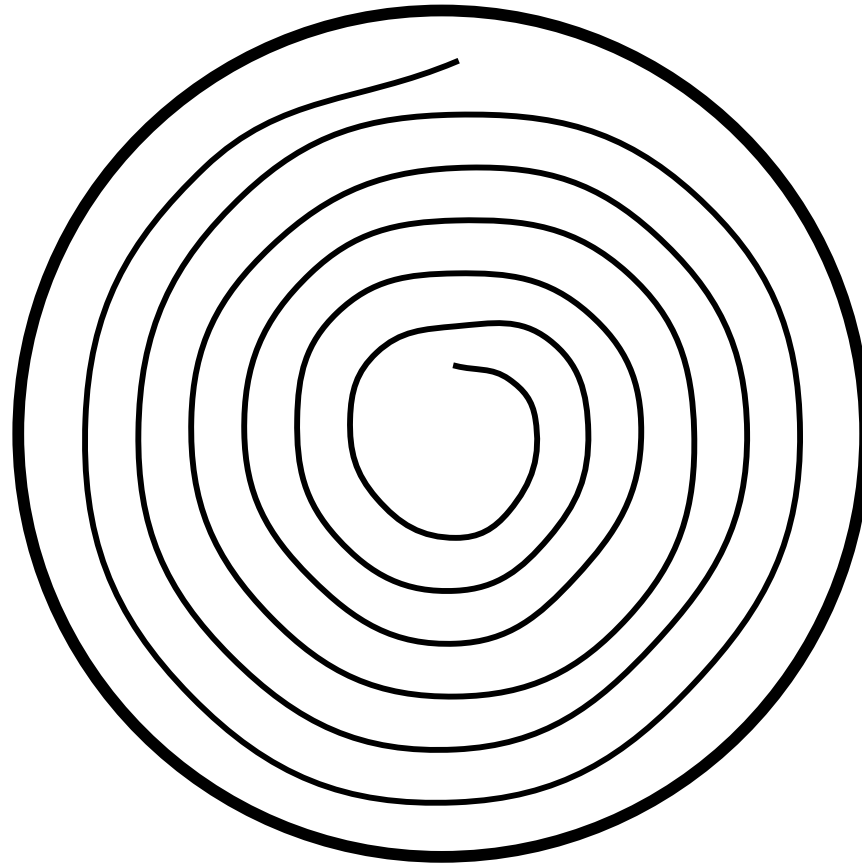
- A portion of a magnetic tape (adapted from [Hamacher, 1990]).



# Magnetic Drum



# Spiral Format for Compact Disk



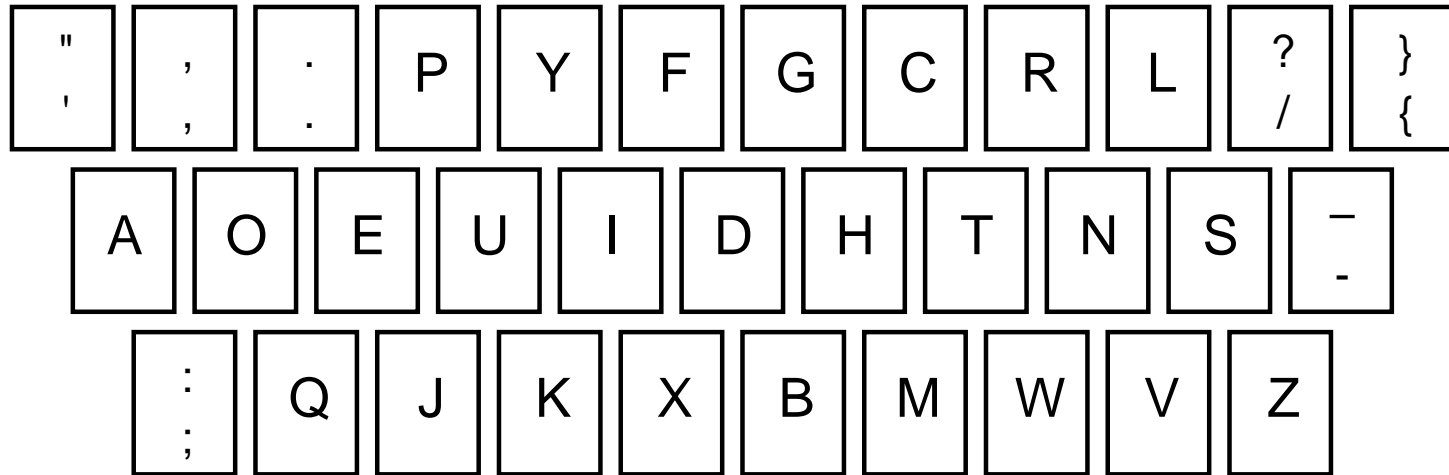


# ECMA-23 Keyboard Layout

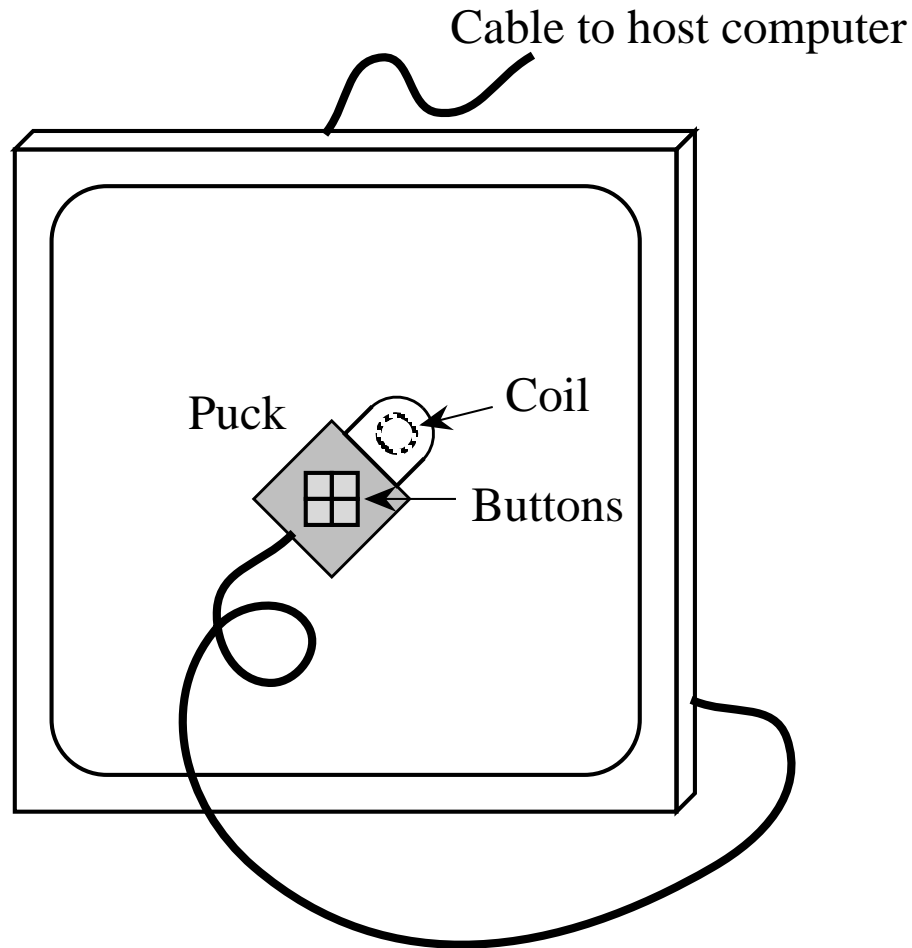
- Keyboard layout for the ECMA-23 Standard (2nd ed.). Shift keys are frequently placed in the B row.

	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18
F																				
E		⌵	! 1	" 2	# 3	⌘ 4	% 5	& 6	' 7	( 8	) 9	0	=	⌵ ^						
D			Q	W	E	R	T	Y	U	I	O	P	' @	{			7	8	9	
C			A	S	D	F	G	H	J	K	L	+ ;	* :	}		-	4	5	6	
B		⌵	Z	X	C	V	B	N	M	< ,	> .	? /					1	2	3	
A			[Shift Key]													0	00	.	SP	
Z																				

# The Dvorak Keyboard Layout

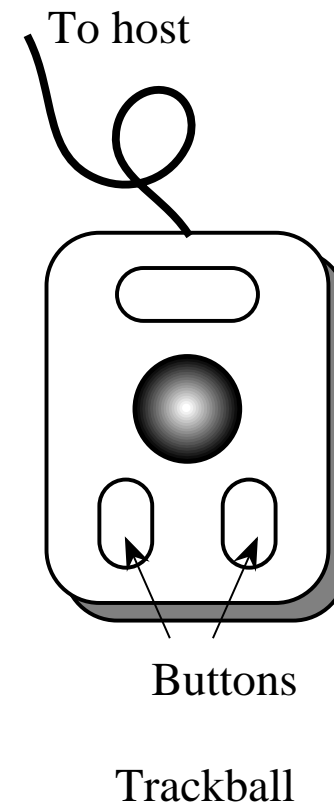
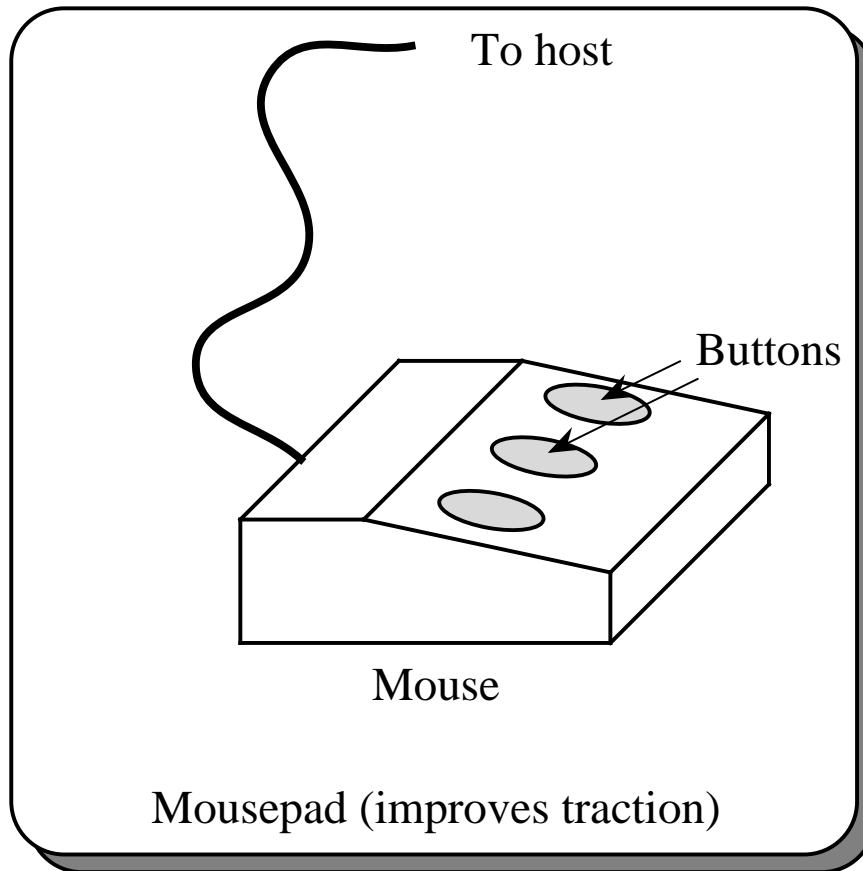


# Bit Pad with Puck



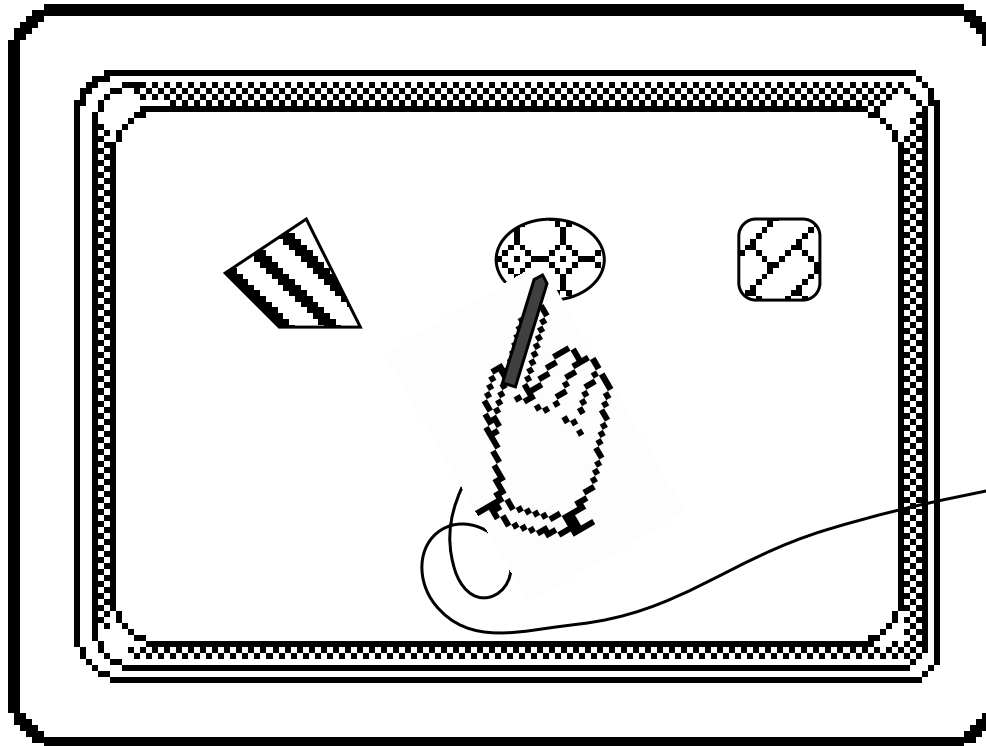
# Mouse and Trackball

- A three-button mouse (left) and a three-button trackball (right).



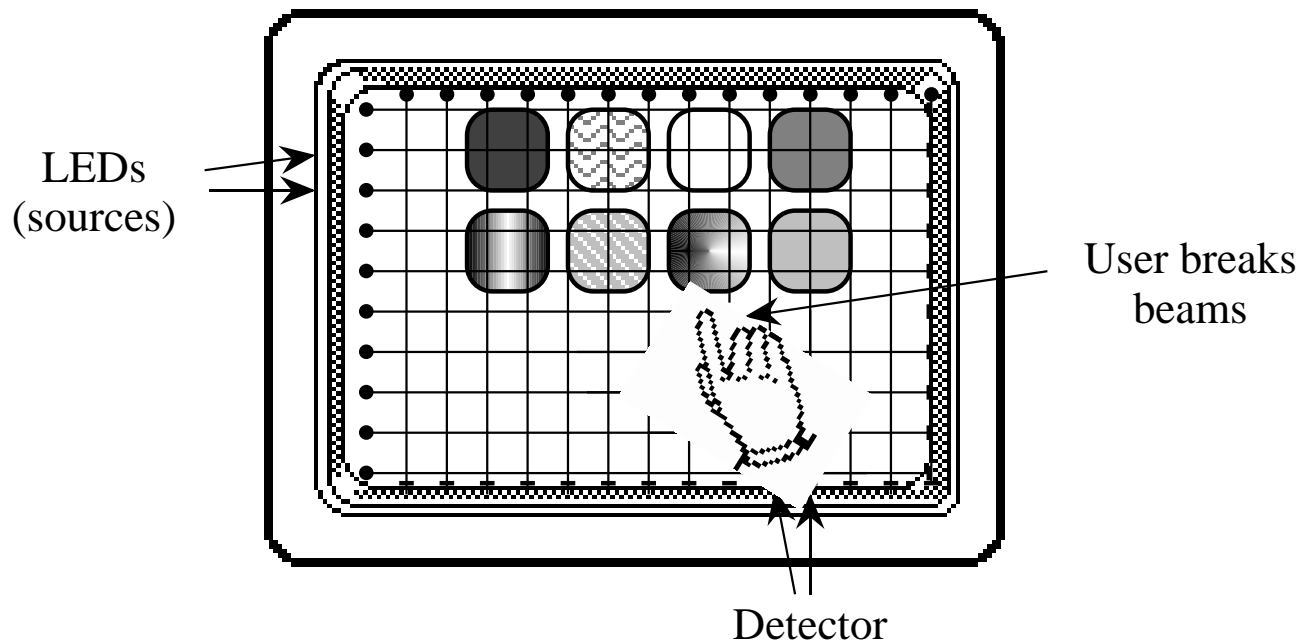
# Lightpen

- A user selects an object with a lightpen.



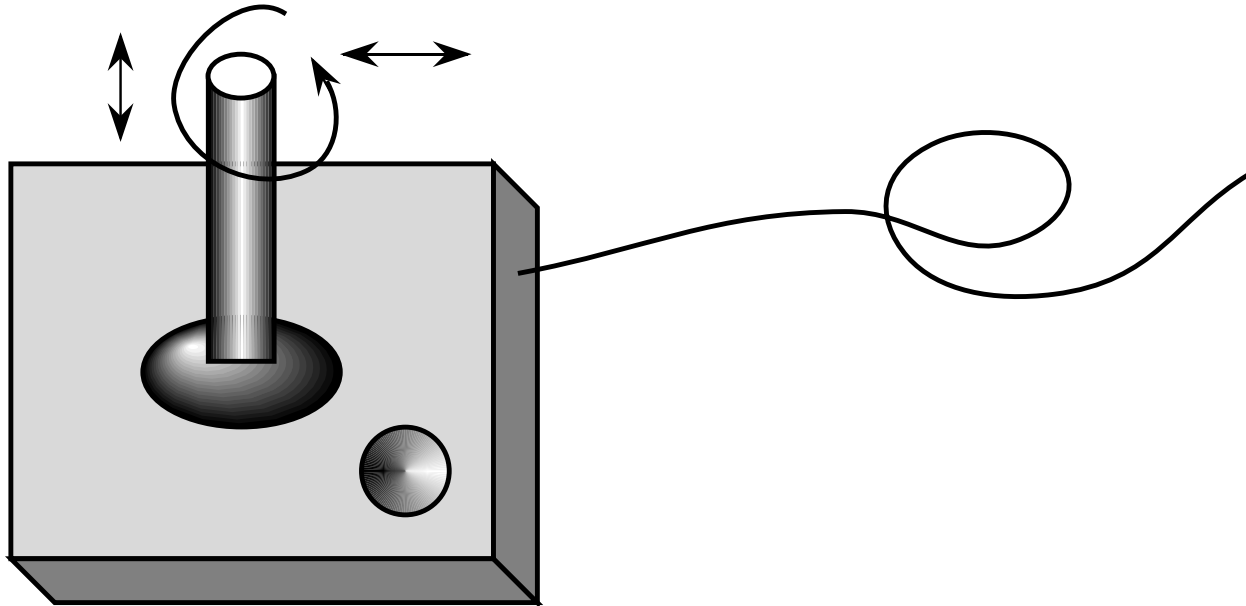
# Touchscreen

- A user selects an object on a touchscreen.



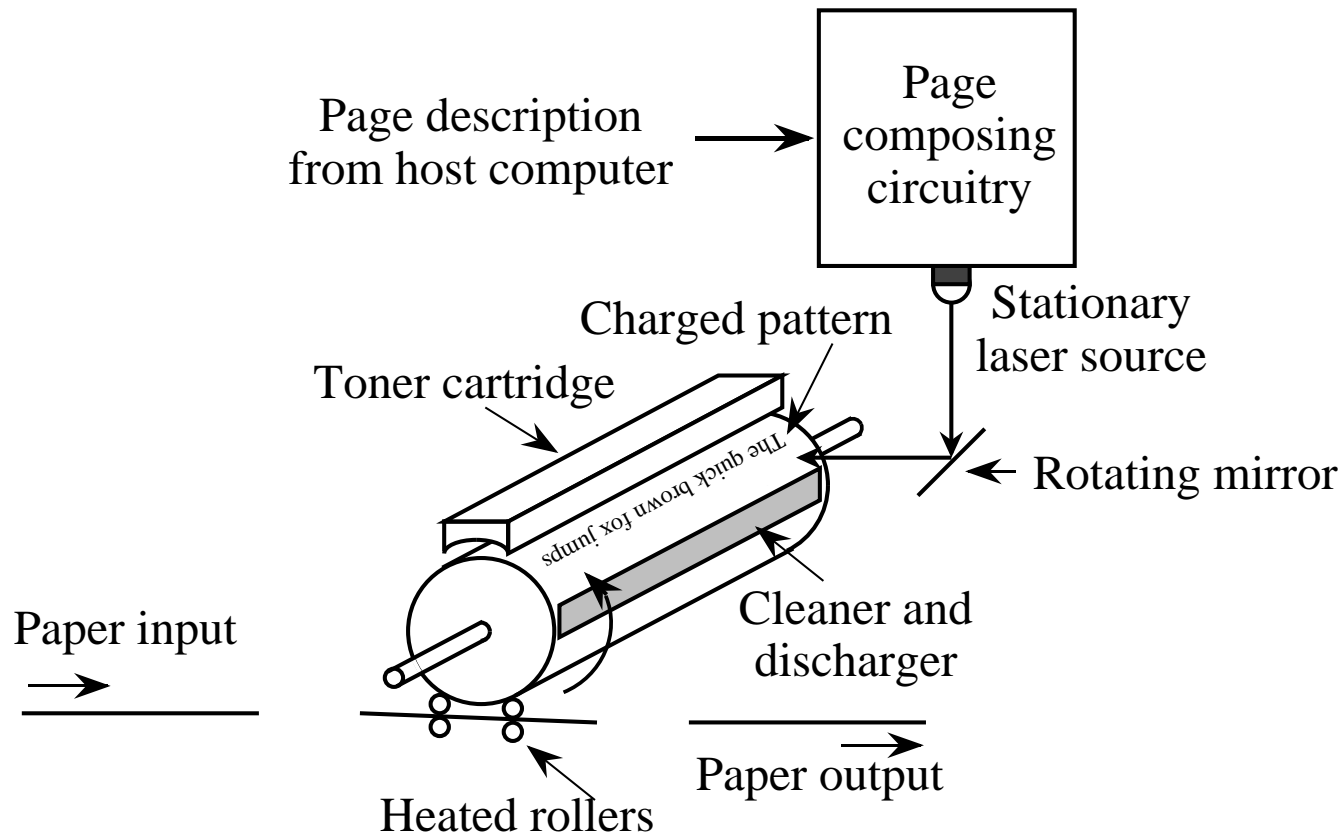
# Joystick

- A joystick with a selection button and a rotatable rod:



# Laser Printer

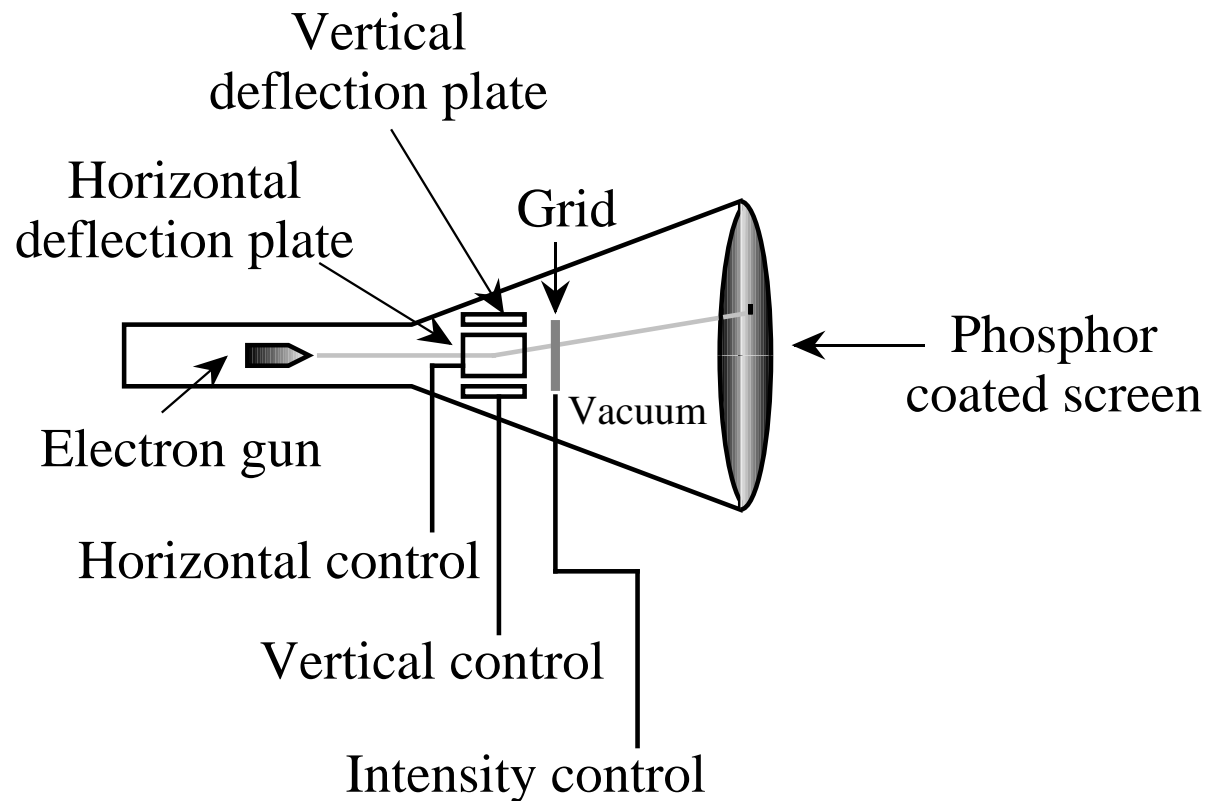
- Schematic of a laser printer (adapted from [Tanenbaum, 1999]).





# Cathode Ray Tube

- A CRT with a single electron gun:



# Display Controller

- Display controller for a 640×480 color monitor (adapted from [Hamacher et al., 1990]).

