ĐẠI HỌC ĐÀ NẴNG
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CHAPTER 5 – INPUT/OUTPUT

- I/O hardware management
- I/O software management
- Disk management
- User Interface management

Types of I/O devices

Two main groups: Block and Character Devices

- Block devices include disk drives
  - Commands include read, write, seek
  - Raw I/O or file-system access
  - Memory-mapped file access possible
- Character devices include keyboards, mice, serial ports
  - Commands include `get, put`
  - Libraries layered on top allow line editing

Types of I/O devices

Some typical device, network, and data base rates

Device	Data rate
Keyboard	10 bytes/sec
Mouse	100 bytes/sec
56K modem	7 KB/sec
Telephone channel	8 KB/sec
Dual ISDN lines	16 KB/sec
Laser printer	100 KB/sec
Scanner	400 KB/sec
Classic Ethernet	1.25 MB/sec
USB (Universal Serial Bus)	1.5 MB/sec
Digital camcorder	4 MB/sec
IDE disk	5 MB/sec
40x CD-ROM	6 MB/sec
Fast Ethernet	12.5 MB/sec
ISA bus	16.7 MB/sec
EIDE (ATA-2) disk	16.7 MB/sec
FireWire (IEEE 1394)	50 MB/sec
XGA Monitor	60 MB/sec
SONET OC-12 network	78 MB/sec
SCSI Ultra 2 disk	80 MB/sec
Gigabit Ethernet	125 MB/sec
Ultrium tape	320 MB/sec
PCI bus	528 MB/sec
Sun Gigaplane XB backplane	20 GB/sec

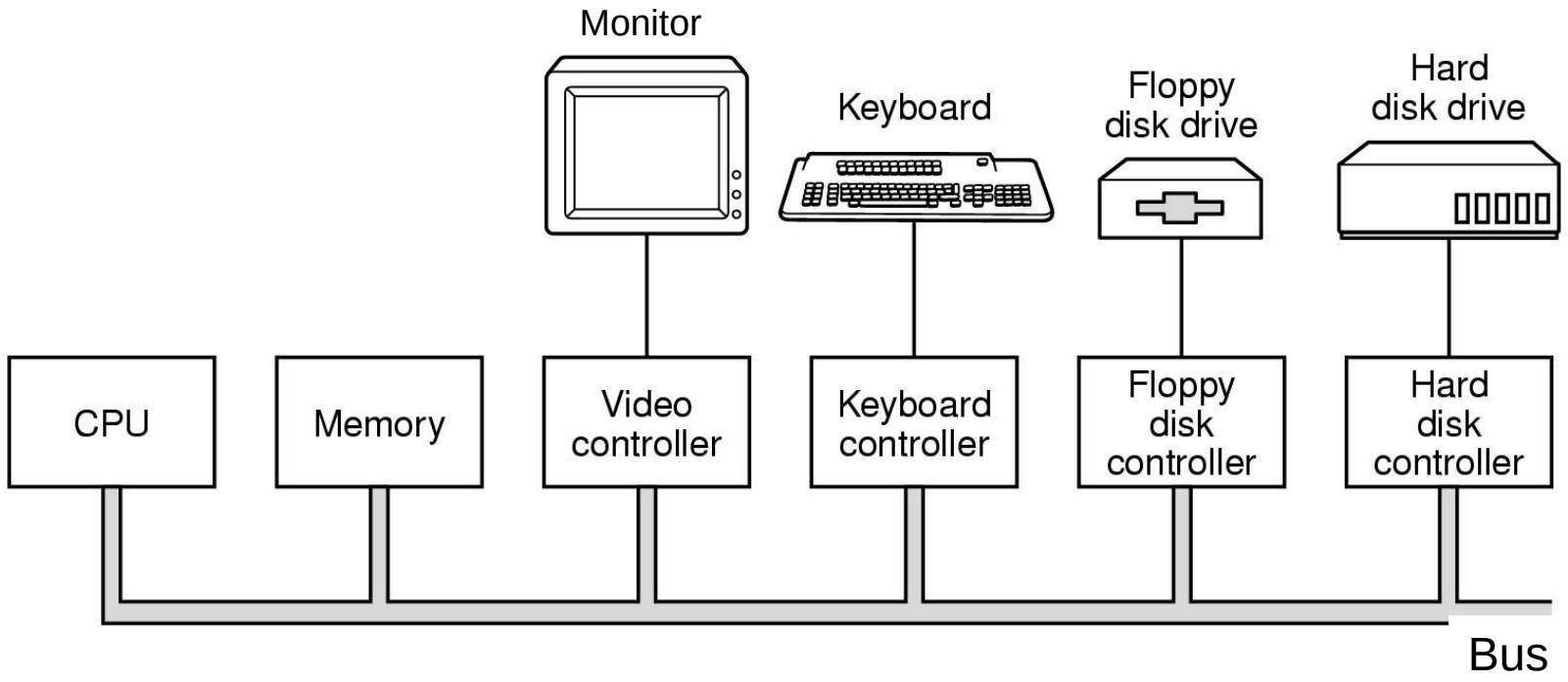
Common concepts

Common concepts

- I/O Device Controller
- I/O Port
- I/O Bus

Device Controllers

- Components of a simple personaı computer



Device Controllers

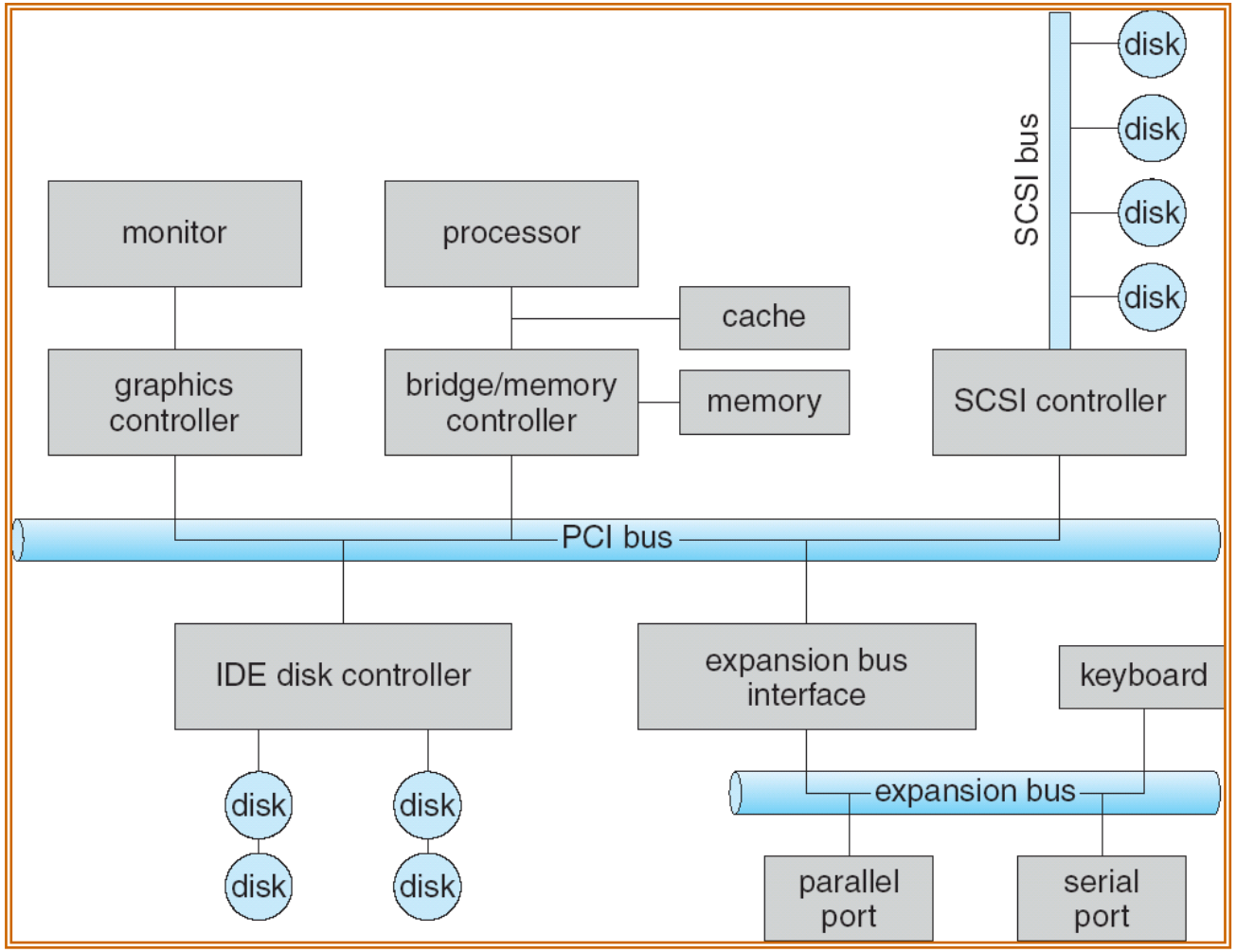
- I/O devices have components:
  - electromechanical component
  - electronic component
- The electronic component is the device controller
  - may be able to handle multiple devices
- Controller's tasks (Disk)
  - convert serial bit stream to block of bytes
  - perform error correction as necessary
  - make available to main memory

I/O Port

I/O Port is a register in device interface. Example: Device I/O Port Locations on PCs (partial)

I/O address range (hexadecimal)	device
000–00F	DMA controller
020–021	interrupt controller
040–043	timer
200–20F	game controller
2F8–2FF	serial port (secondary)
320–32F	hard-disk controller
378–37F	parallel port
3D0–3DF	graphics controller
3F0–3F7	diskette-drive controller
3F8–3FF	serial port (primary)

A Typical PC Bus Structure

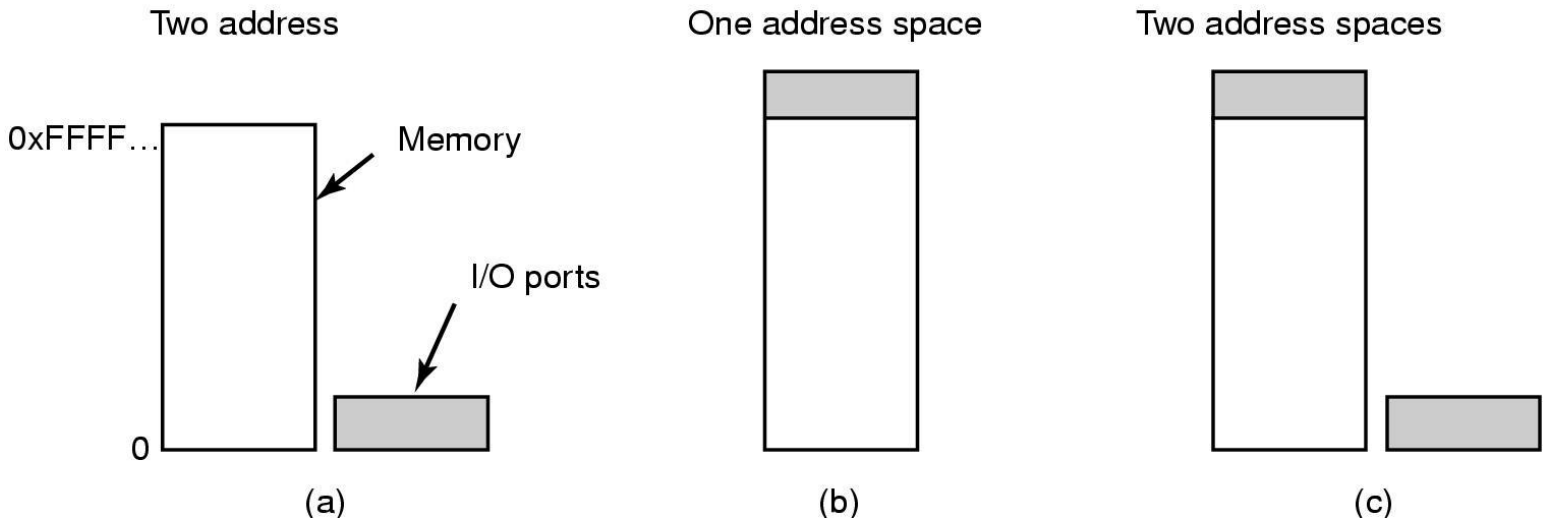


I/O address

- I/O instructions control devices
- Devices have addresses, used by
  - Direct I/O instructions
  - Memory-mapped I/O

Memory-Mapped I/O (1)

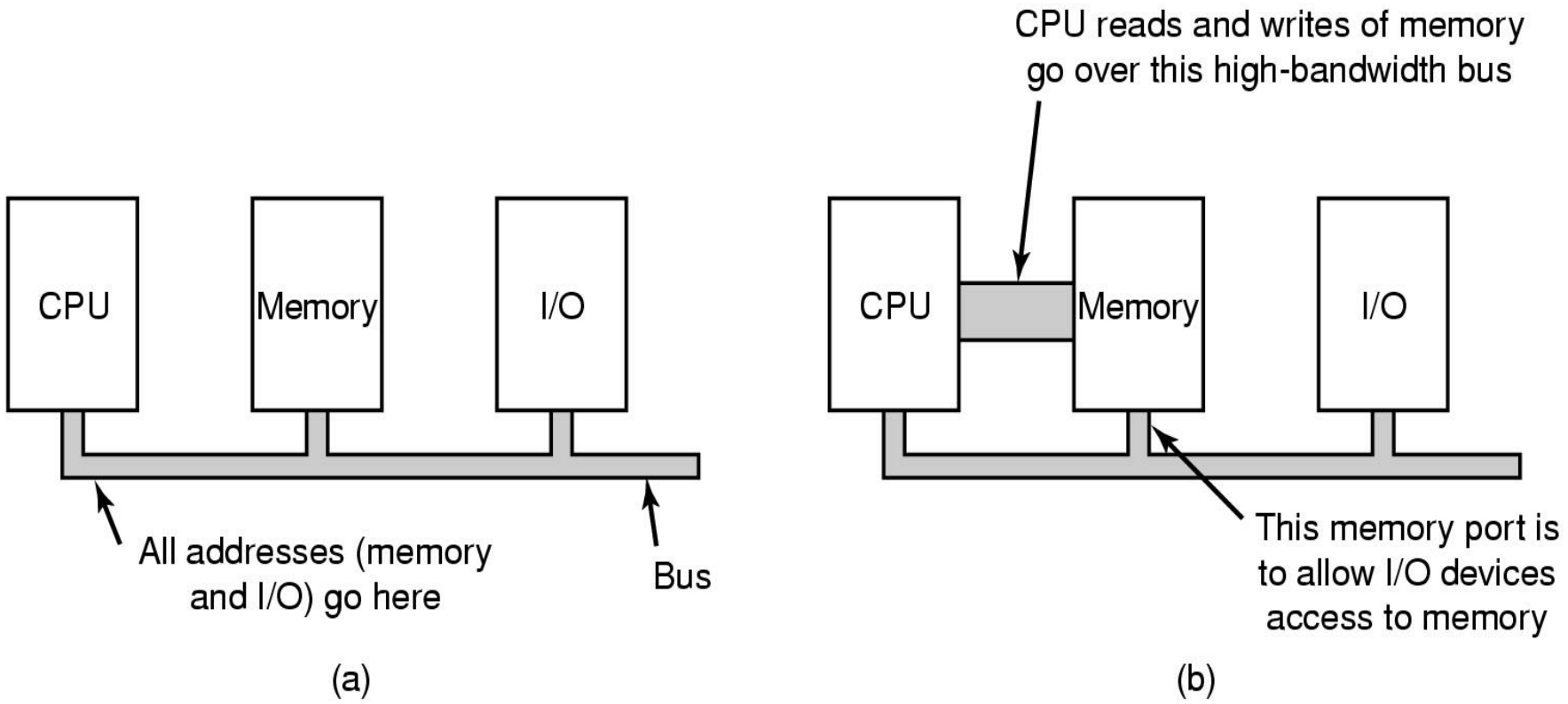
- Separate I/O and memory space
- Memory-mapped I/O
- Hybrid



Memory-Mapped I/O (2)

(a) A single-bus architecture

(b) A dual-bus memory architecture



Data transfer Method between CPU and I/O device

Three Data I/O transfer Methods:

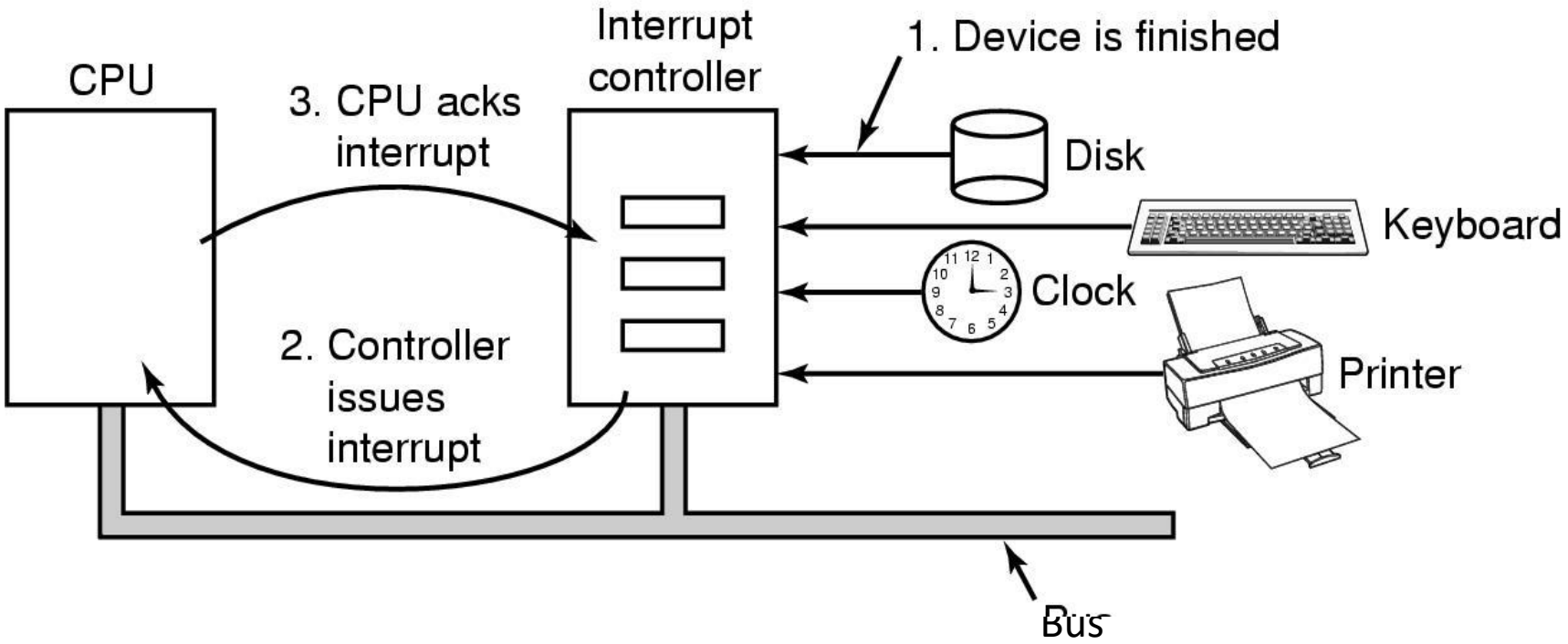
- Programmed I/O
- Interrupt-Driven I/O
- Direct Memory Access

Programmed I/O, Polling

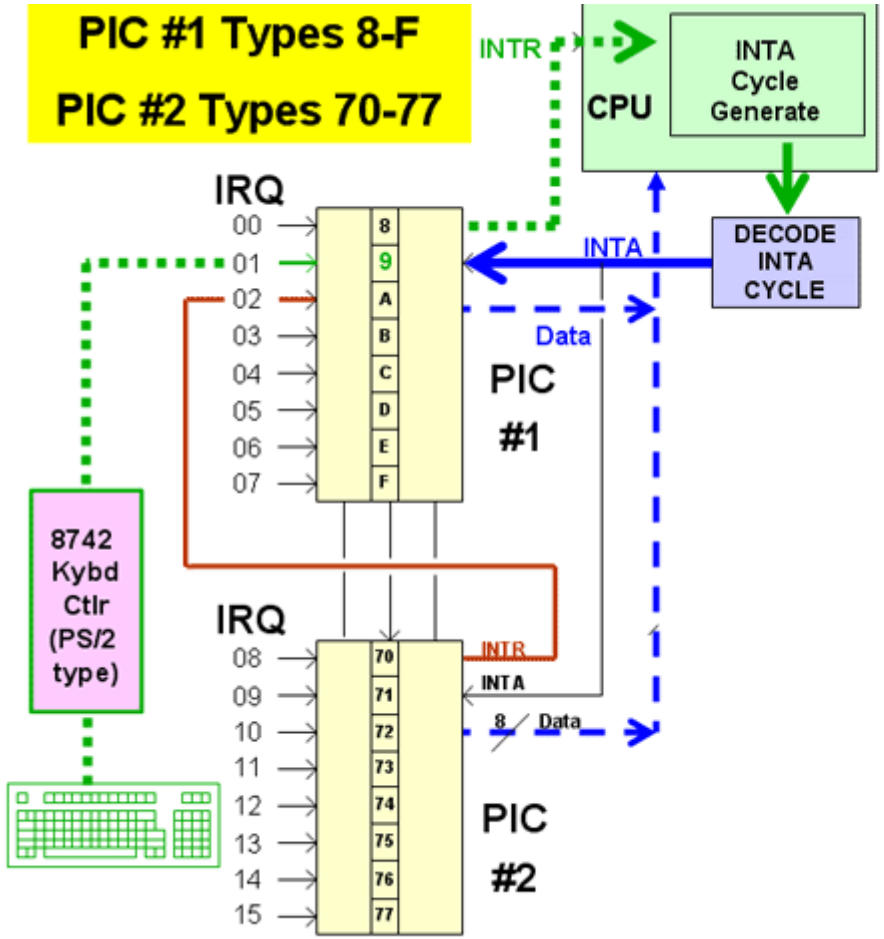
- Determines state of device
  - ready
  - busy
  - Error
- **Busy-wait** cycle to wait for I/O from device

Interrupt-Driven I/O

How interrupts happens. Connections between devices and interrupt controller actually use interrupt lines on the bus rather than dedicated wires



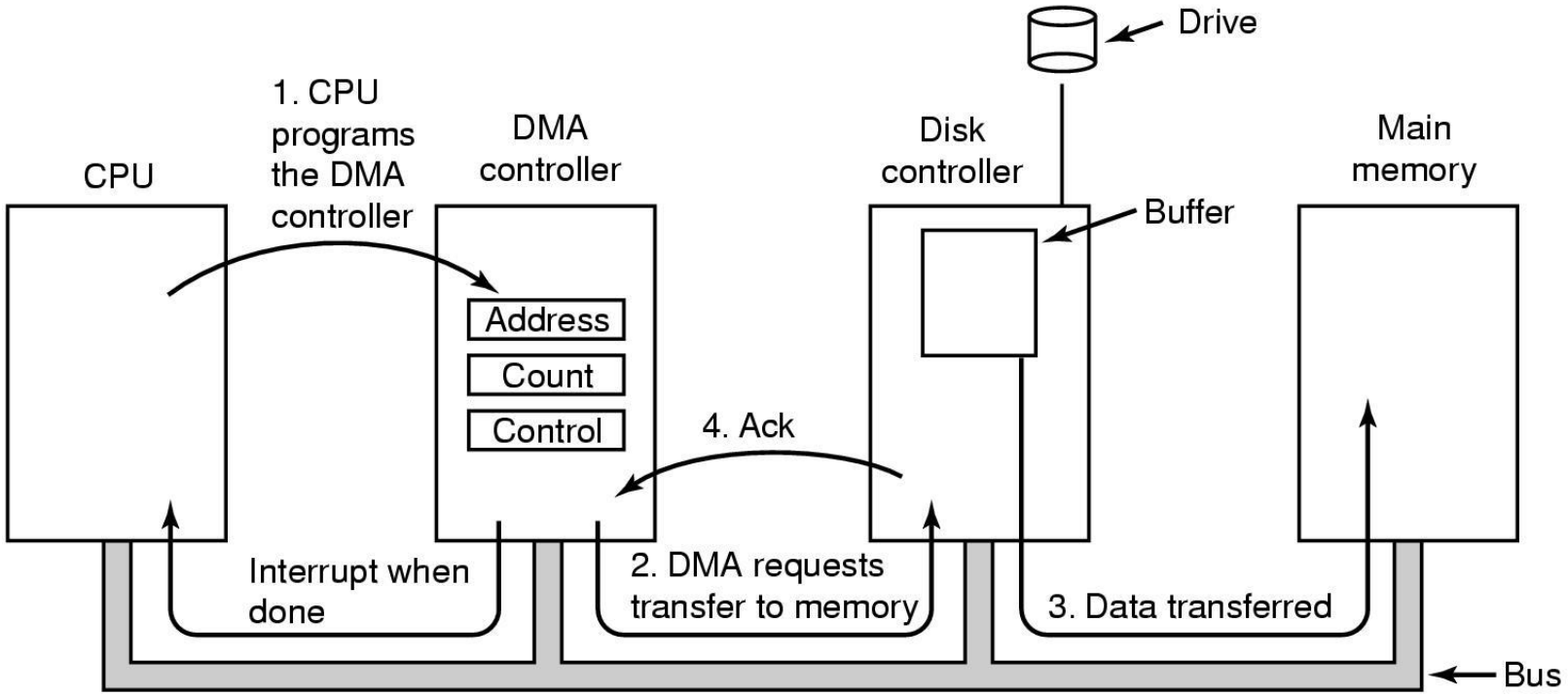
Example: Interrupts of PC computer



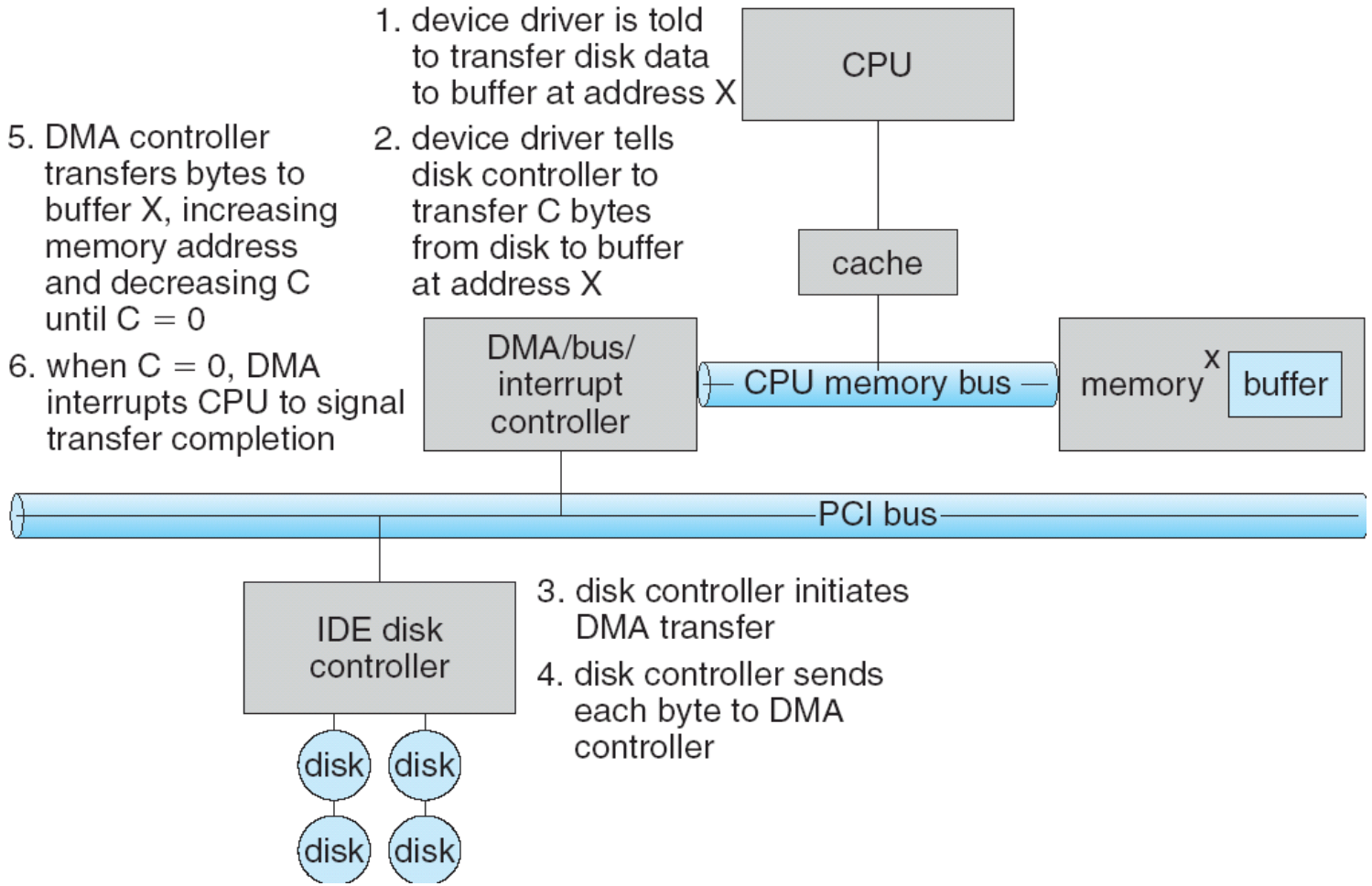
INT. NO	Interrupt Source
NMI	Parity Error Detected
IRQ0	Interval Timer (PIT)
IRQ1	Keyboard Output Buffer
IRQ2	PIC 2 (Cascade)
IRQ8	Real-time Clock Int
IRQ9	S/W Redirected To Int 0ah (IRQ2)--free
IRQ10	Free
IRQ11	Free
IRQ12	Free (PS/2 Mouse)
IRQ13	reserved--math coprocesso
IRQ14	Pri EIDE Fixed Disk
IRQ15	Sec EIDE Fixed Disk
IRQ3	COM2
IRQ4	COM1 (Primary)
IRQ5	Free (Sound Card, LPT2)
IRQ6	Floppy Disk Controller
IRQ7	LPT1 (Primary) Or Free

Direct Memory Access (DMA)

Operation of a DMA transfer



Example: DMA Transfer in PC Computer



Goals of I/O Software (1)

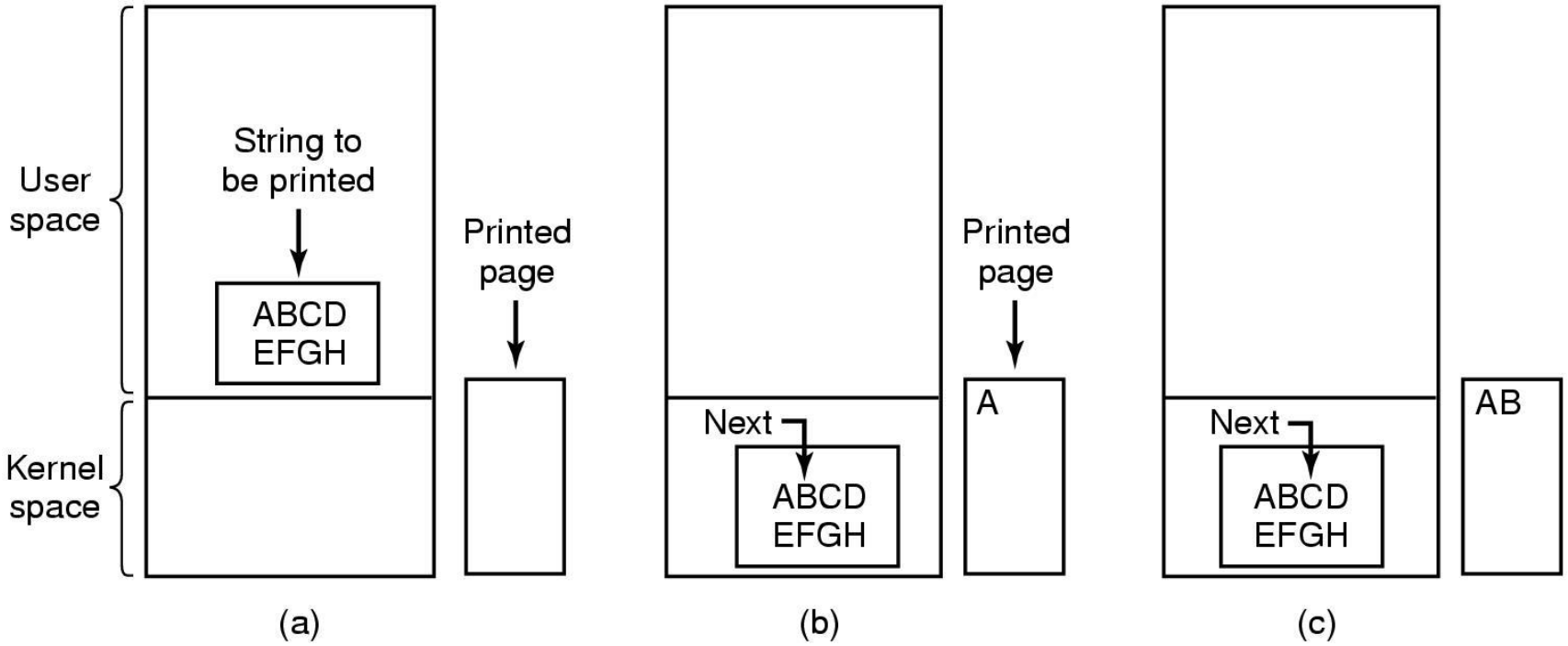
- Device independence
  - programs can access any I/O device
  - without specifying device in advance
    (floppy, hard drive, or CD-ROM)
- Uniform naming
  - name of a file or device is a string or an integer
  - not depending on which machine
- Error handling
  - handle as close to the hardware as possible

Goals of I/O Software (2)

- Synchronous vs. asynchronous transfers
  - blocked transfers vs. interrupt-driven
- Buffering
  - data coming off a device cannot be stored in final destination
- Sharable vs. dedicated devices
  - disks are sharable
  - tape drives would not be

Programmed I/O (1)

Steps in printing a string



Programmed I/O (2)

Writing a string to the printer using programmed I/O

```
copy_from_user(buffer, p, count);                /* p is the kernel bufer */
for (i = 0; i < count; i++) {                    /* loop on every character */
        while (*printer_status_reg != READY) ;   /* loop until ready */
        *printer_data_register = p[i];           /* output one character */
}
return_to_user( );
```

Interrupt-Driven I/O

- Writing a string to the printer using interrupt-driven I/O
  - Code executed when print system call is made
  - Interrupt service procedure

```
copy_from_user(buffer, p, count);
enable_interrupts( );
while (*printer_status_reg != READY) ;
*printer_data_register = p[0];
scheduler( );
```

(a)

```
if (count == 0) {
    unblock_user( );
} else {
    *printer_data_register = p[i];
    count = count – 1;
    i = i + 1;
}
acknowledge_interrupt( );
return_from_interrupt( );
```

(b)

I/O Using DMA

- Printing a string using DMA
  - code executed when the print system call is made
  - interrupt service procedure

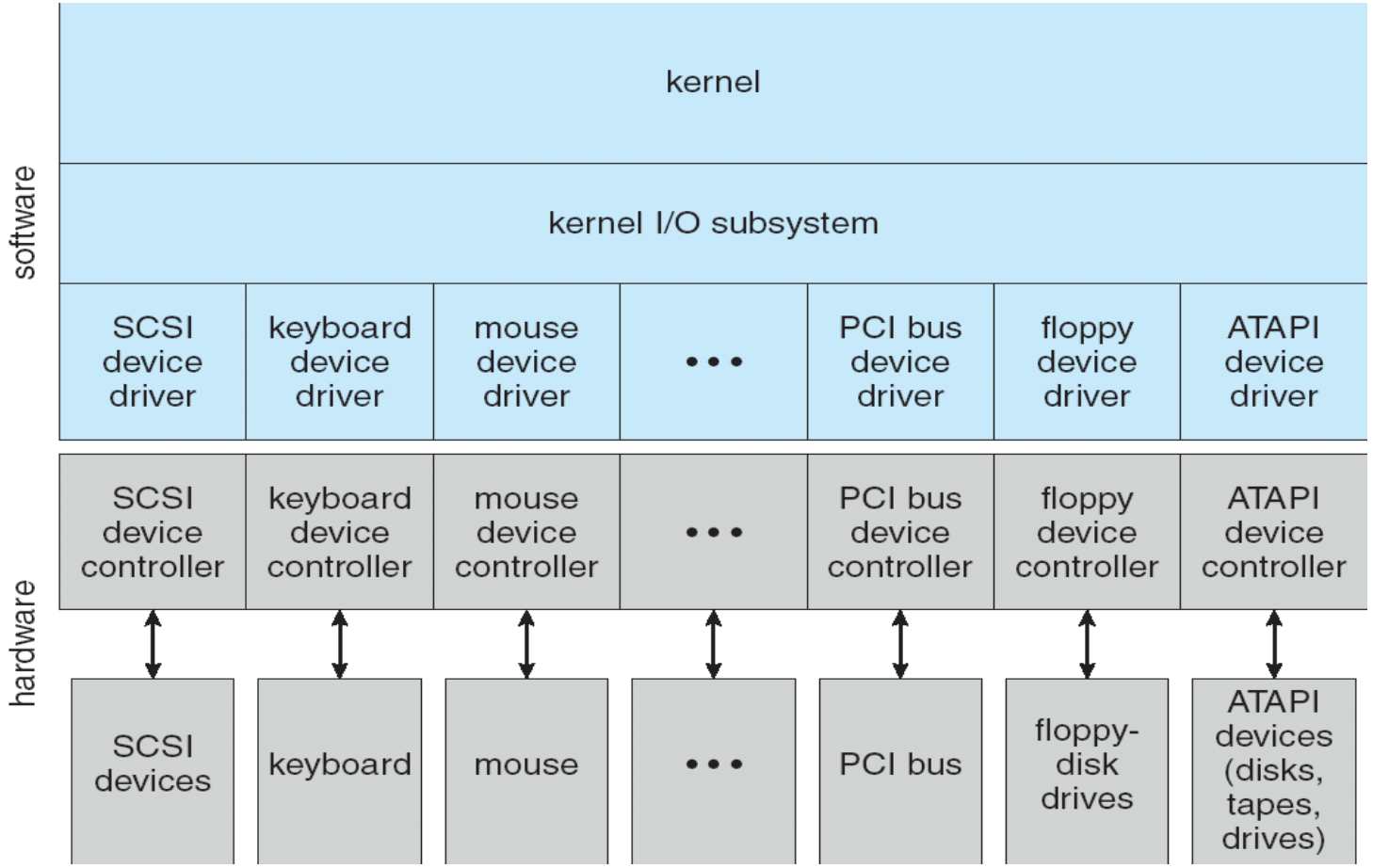
```
copy_from_user(buffer, p, count);
set_up_DMA_controller( );
scheduler( );
```

(a)

```
acknowledge_interrupt( );
unblock_user( );
return_from_interrupt( );
```

(b)

Hardware And Software

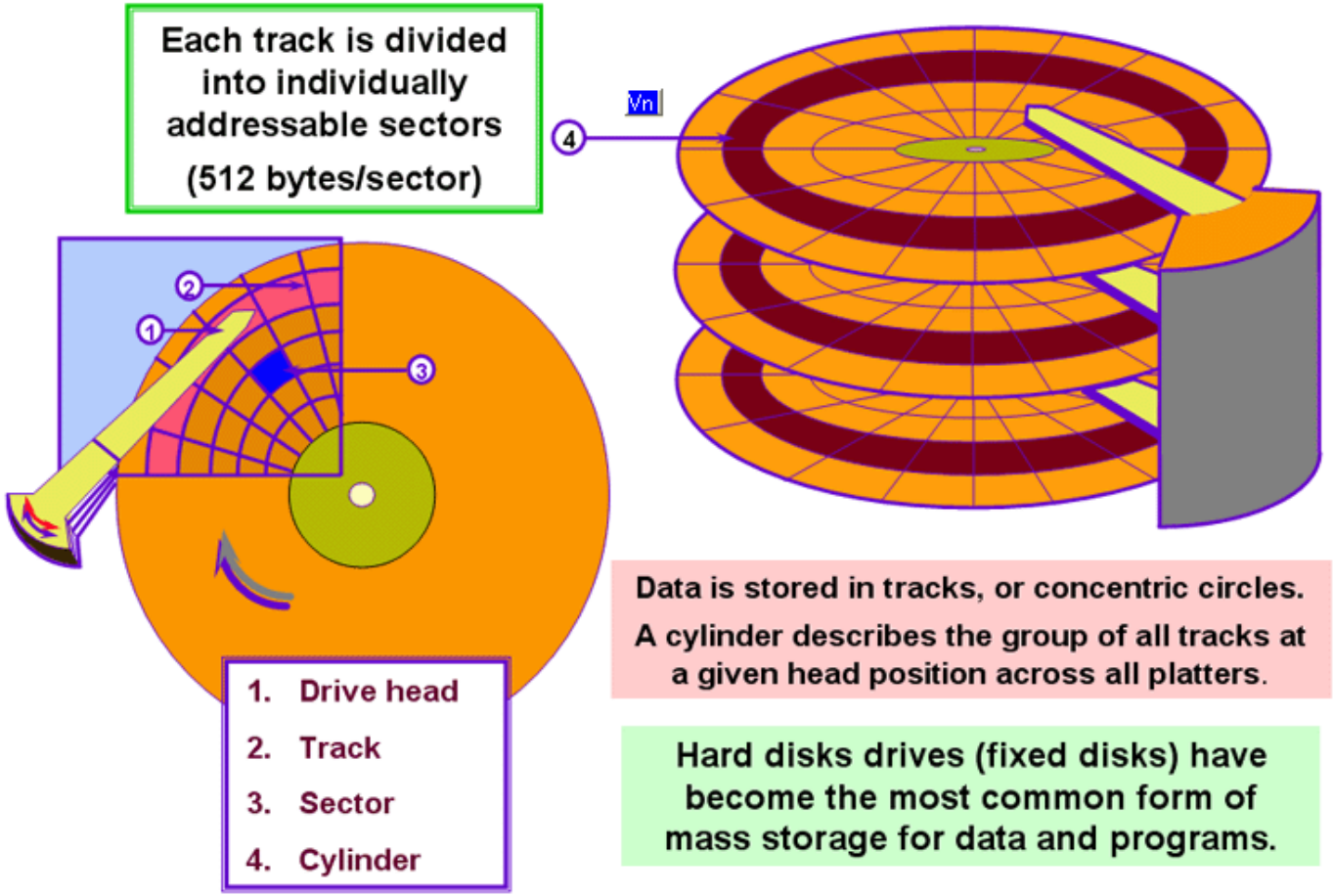


Disk management

Disk parameters for the original IBM PC floppy disk and a Western Digital WD

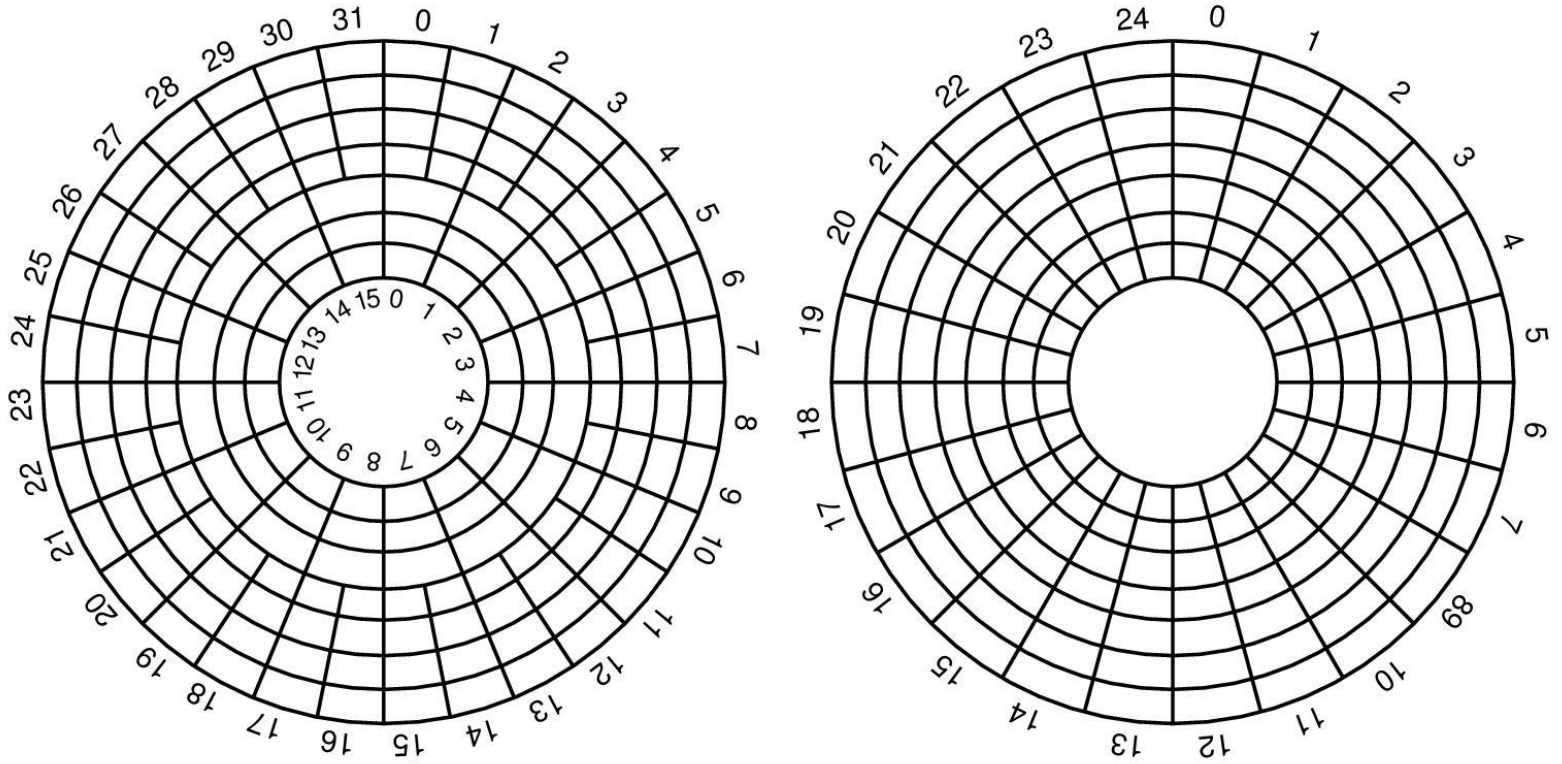
Parameter	IBM 360-KB floppy disk	WD 18300 hard disk
Number of cylinders	40	10601
Tracks per cylinder	2	12
Sectors per track	9	281 (avg)
Sectors per disk	720	35742000
Bytes per sector	512	512
Disk capacity	360 KB	18.3 GB
Seek time (adjacent cylinders)	6 msec	0.8 msec
Seek time (average case)	77 msec	6.9 msec
Rotation time	200 msec	8.33 msec
Motor stop/start time	250 msec	20 sec
Time to transfer 1 sector	22 msec	17 µsec

Disk Hardware (1)



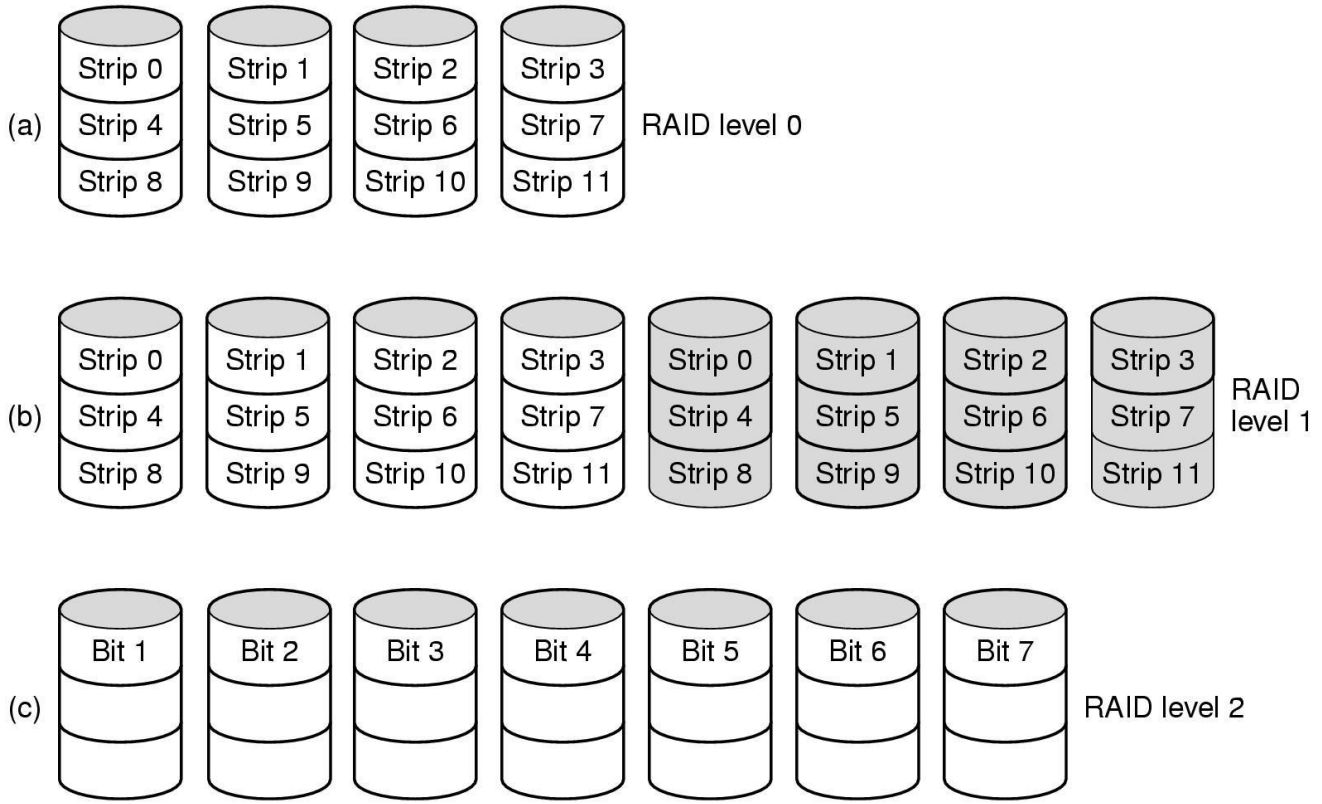
Disk Hardware (2)

- Physical geometry of a disk with two zones
- A possible virtual geometry for this disk



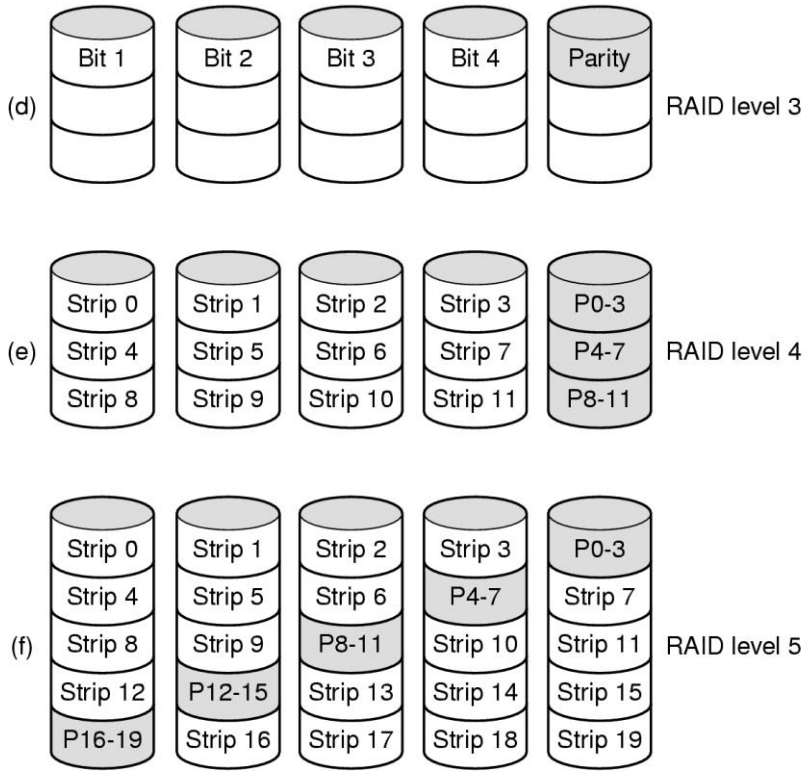
Disk Hardware (3)

- Raid levels 0 through 2
- Backup and parity drives are shaded



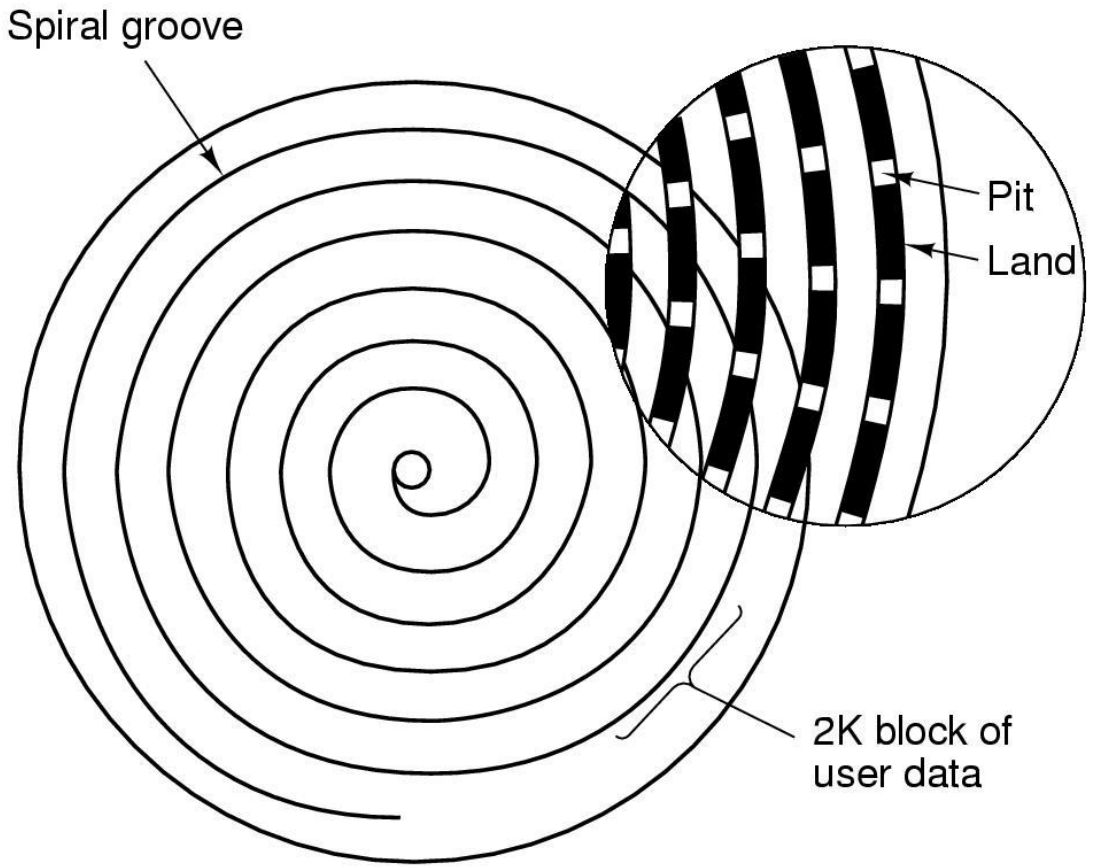
Disk Hardware (4)

- Raid levels 3 through 5
- Backup and parity drives are shaded



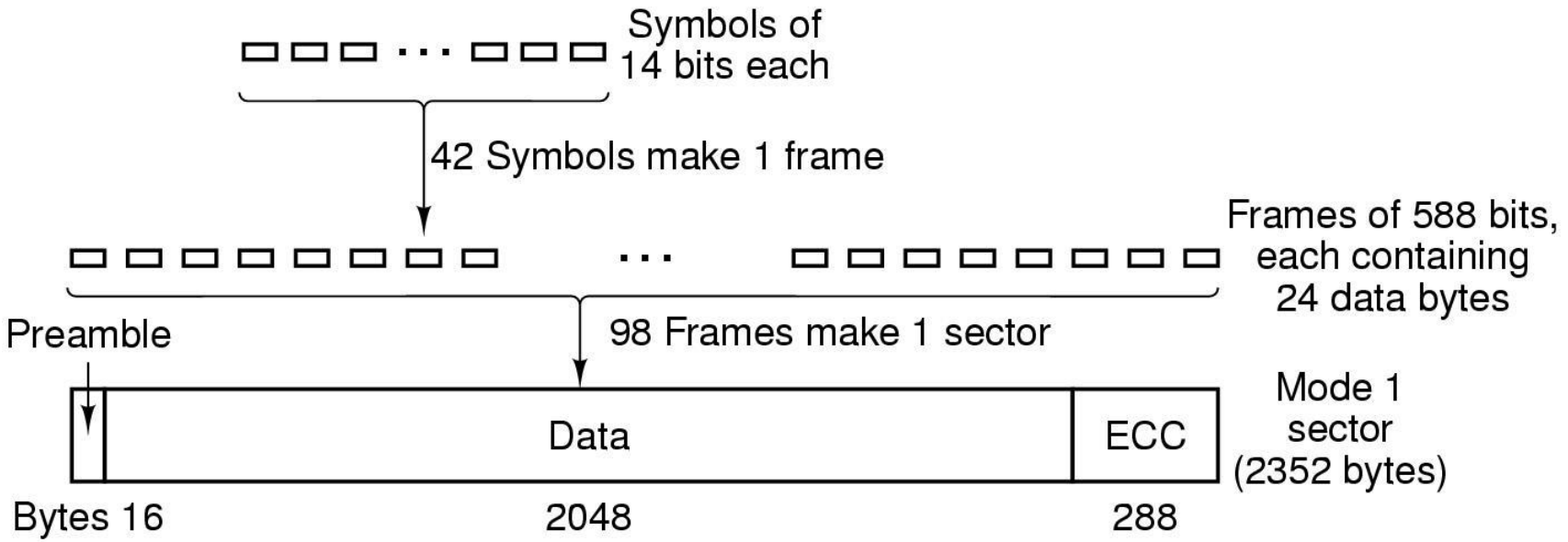
Disk Hardware (5)

Recording structure of a CD or CD-ROM



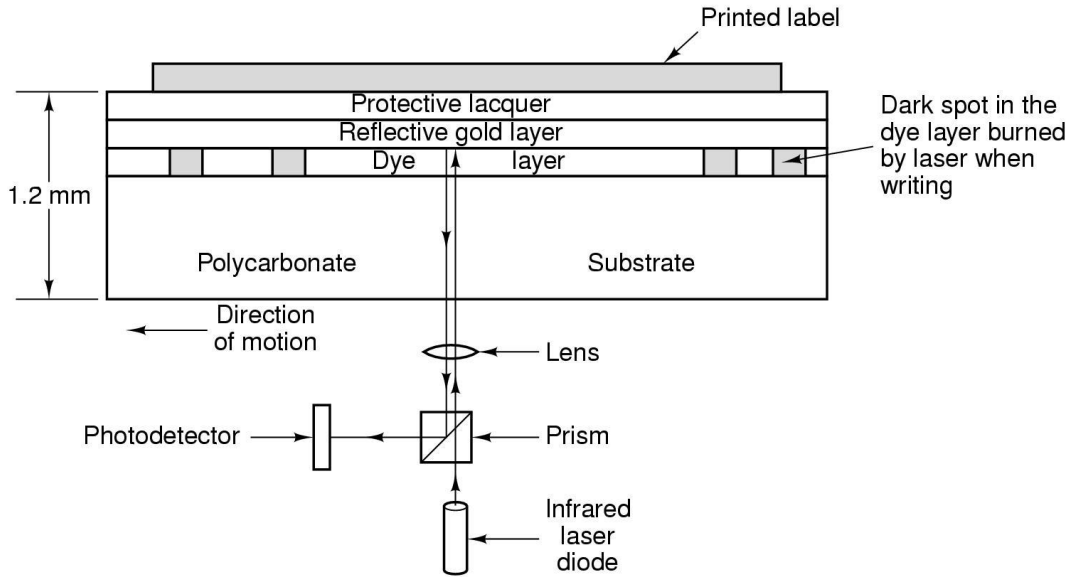
Disk Hardware (6)

Logical data layout on a CD-ROM



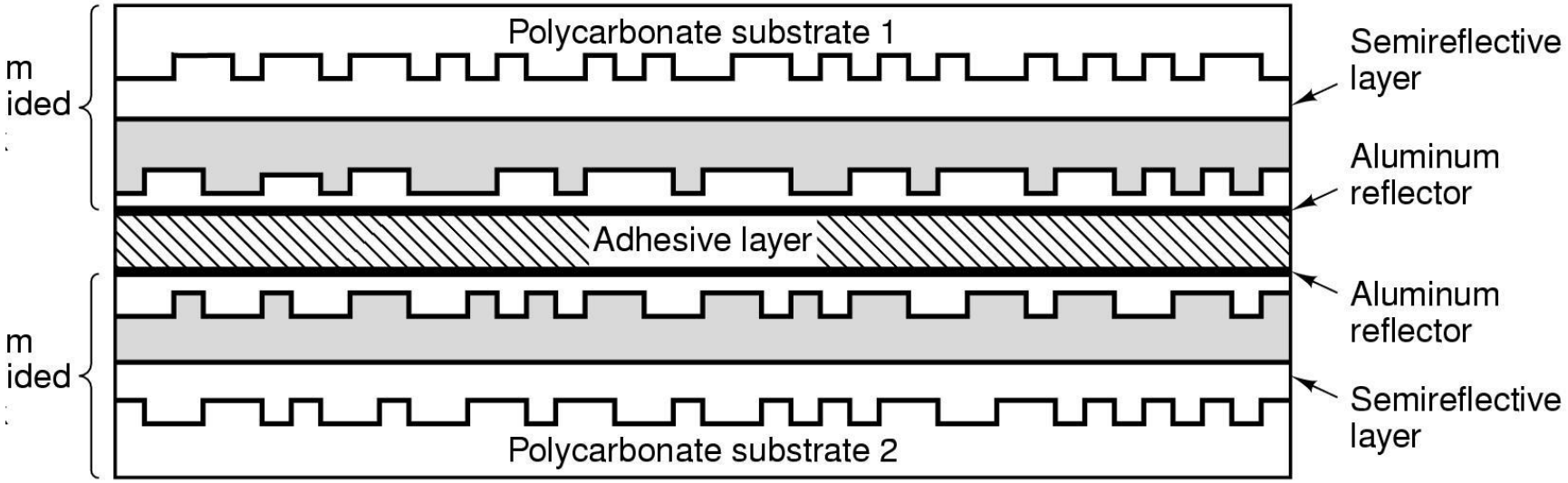
Disk Hardware (7)

- Cross section of a CD-R disk and laser
  - not to scale
- Silver CD-ROM has similar structure
  - without dye layer
  - with pitted aluminum layer instead of gold



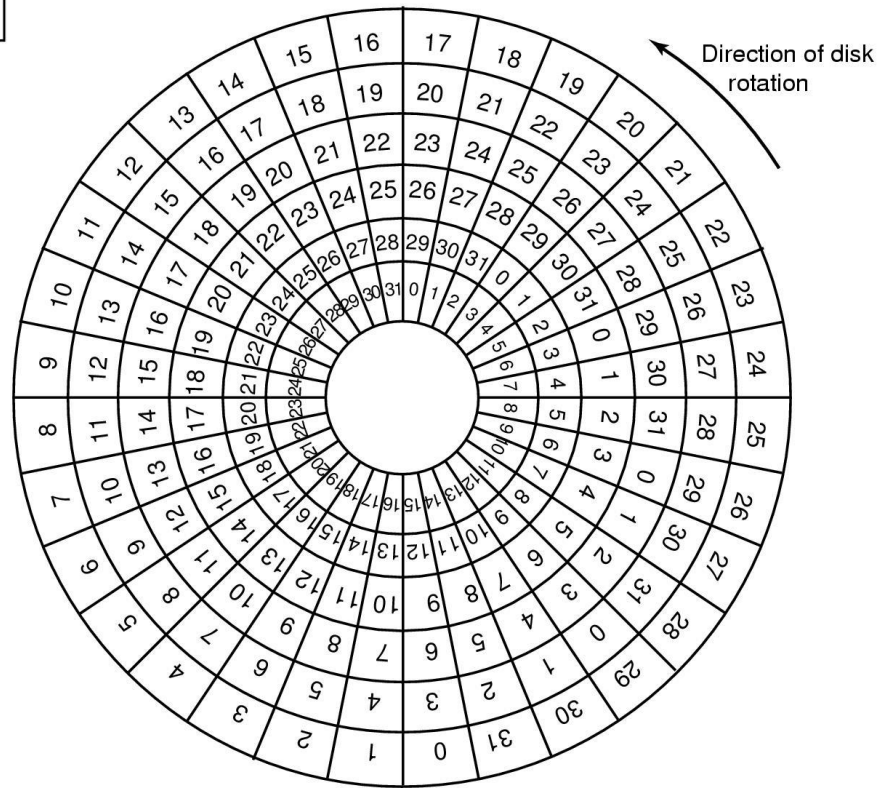
Disk Hardware (8)

A double sided, dual layer DVD disk



Disk Formatting (1)

A disk sector



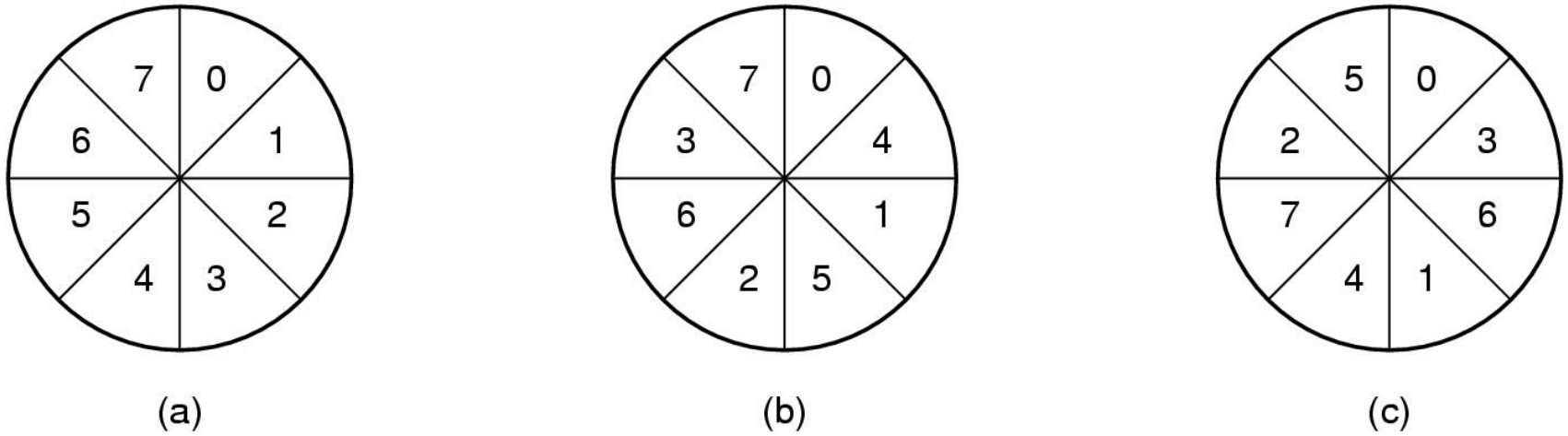
An illustration of cylinder skew

Disk Formatting (2)

(a) No interleaving

(b) Single interleaving

(c) Double interleaving

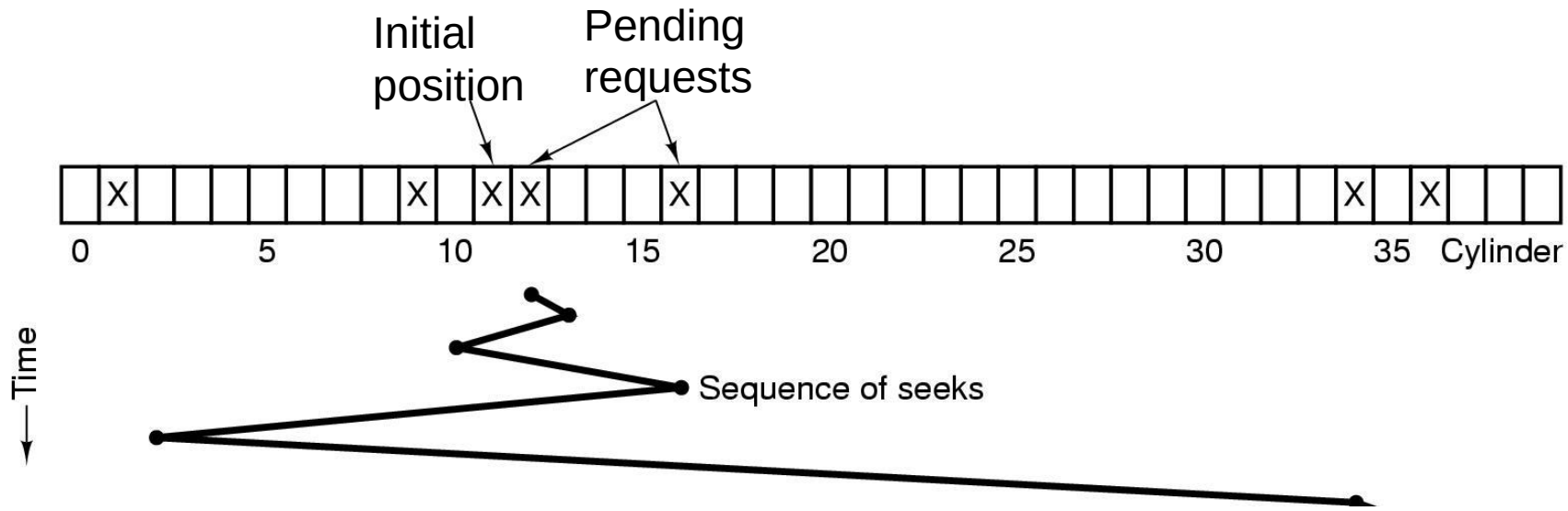


Disk Arm Scheduling Algorithms (1)

- Time required to read or write a disk block determined by 3 factors
  1. Seek time
  2. Rotational delay
  3. Actual transfer time
- Seek time dominates
- Error checking is done by controllers

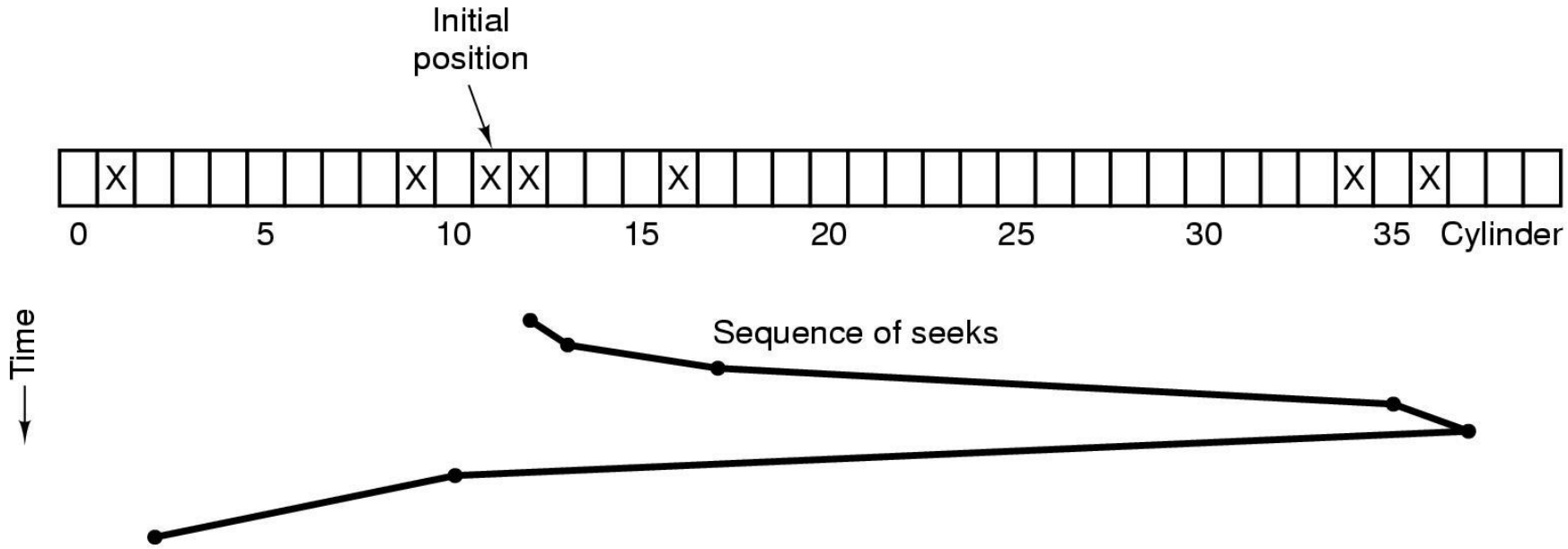
Disk Arm Scheduling Algorithms (2)

Shortest Seek First (SSF) disk scheduling algorithm



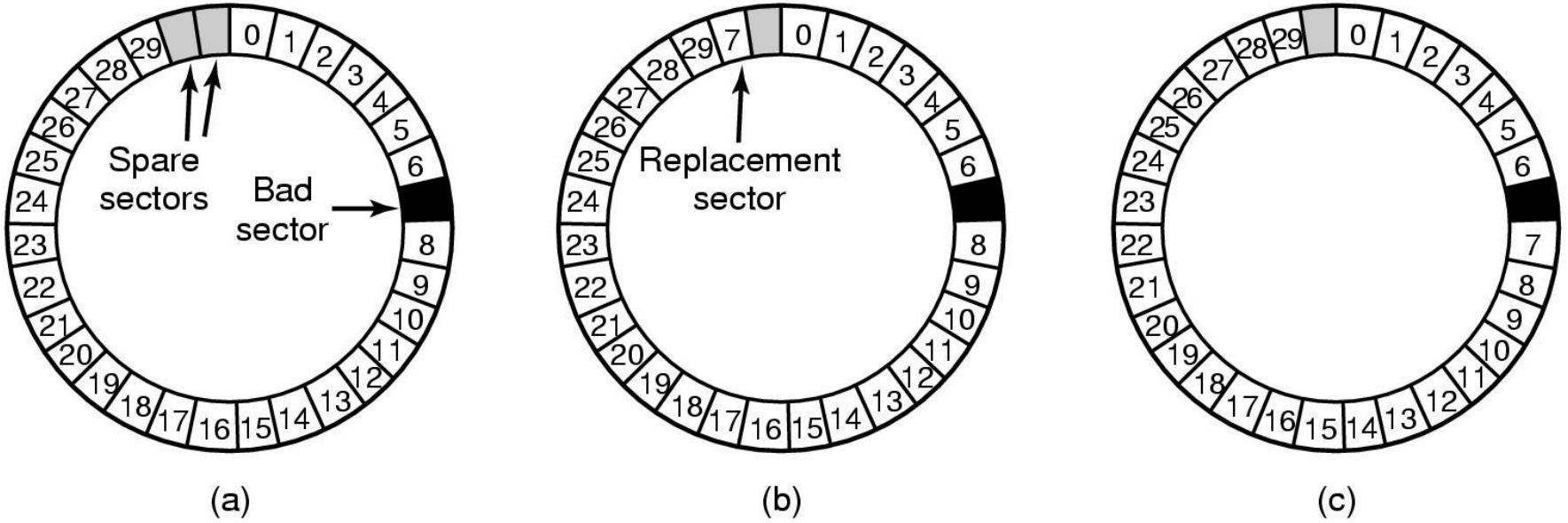
Disk Arm Scheduling Algorithms (3)

The elevator algorithm for scheduling disk requests



Error Handling

- A disk track with a bad sector
- Substituting a spare for the bad sector
- Shifting all the sectors to bypass the bad one

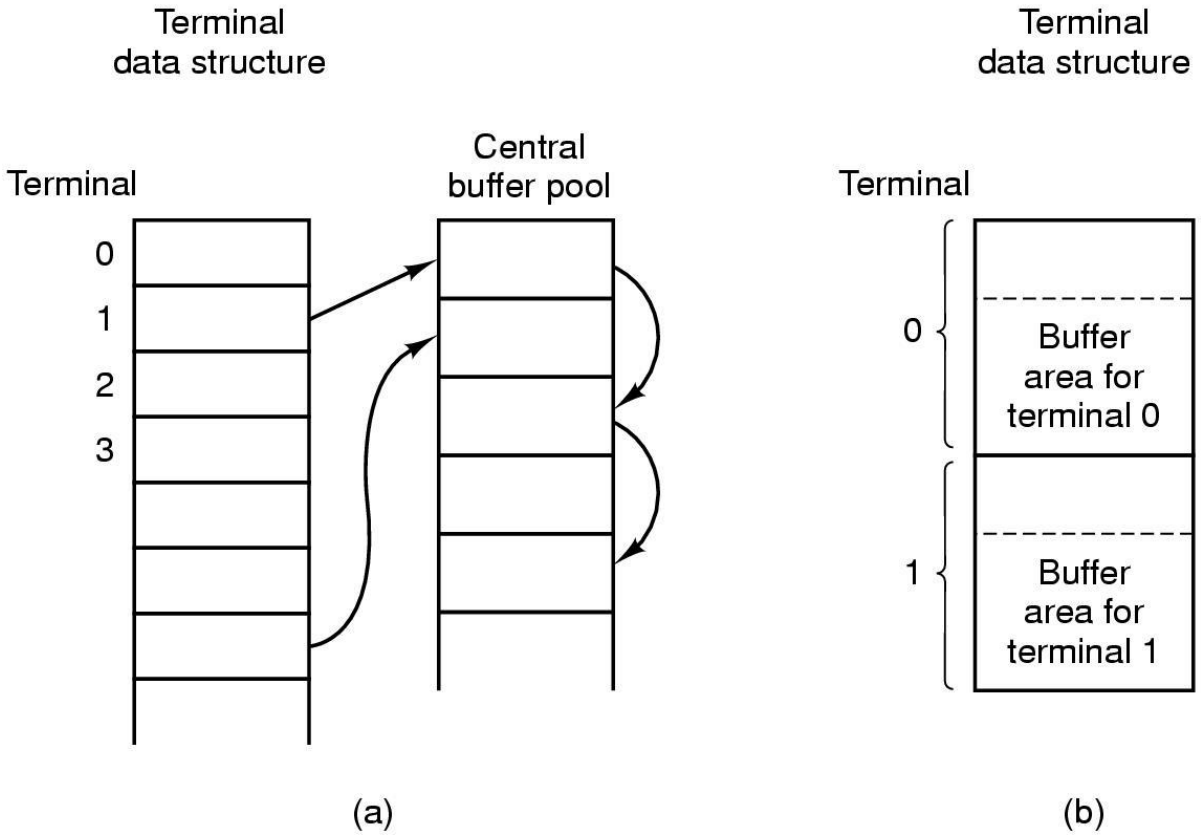


User Interface management

- Input Software
- Output Software

Input Software

- Central buffer pool
- Dedicated buffer for each terminal



Input Software

Characters handled specially in canonical mode

Character	POSIX name	Comment
CTRL-H	ERASE	Backspace one character
CTRL-U	KILL	Erase entire line being typed
CTRL-V	LNEXT	Interpret next character literally
CTRL-S	STOP	Stop output
CTRL-Q	START	Start output
DEL	INTR	Interrupt process (SIGINT)
CTRL-\	QUIT	Force core dump (SIGQUIT)
CTRL-D	EOF	End of file
CTRL-M	CR	Carriage return (unchangeable)
CTRL-J	NL	Linefeed (unchangeable)

Input Software

- Keyboard driver delivers a number
  - driver converts to characters
  - uses a ASCII table
- Exceptions, adaptations needed for other languages
  - many OS provide for loadable keymaps or code pages

Output Software

The ANSI escape sequences

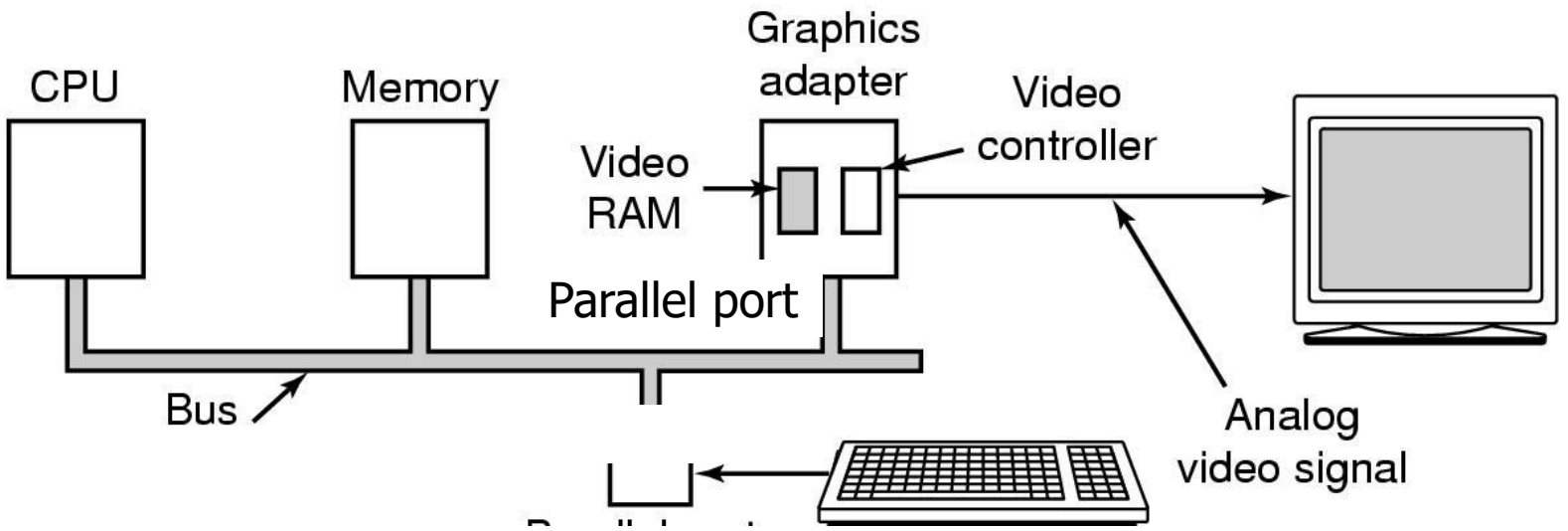
- accepted by terminal driver on output
- ESC is ASCII character (0x1B)
- n,m, and s are optional numeric parameters

Escape sequence	Meaning
ESC [*n* A	Move up *n* lines
ESC [*n* B	Move down *n* lines
ESC [*n* C	Move right *n* spaces
ESC [*n* D	Move left *n* spaces
ESC [*m* ; *n* H	Move cursor to (*m*,*n*)
ESC [*s* J	Clear screen from cursor (0 to end, 1 from start, 2 all)
ESC [*s* K	Clear line from cursor (0 to end, 1 from start, 2 all)
ESC [*n* L	Insert *n* lines at cursor
ESC [*n* M	Delete *n* lines at cursor
ESC [*n* P	Delete *n* chars at cursor
ESC [*n* @	Insert *n* chars at cursor
ESC [*n* m	Enable rendition *n* (0=normal, 4=bold, 5=blinking, 7=reverse)
ESC M	Scroll the screen backward if the cursor is on the top line

Display Hardware (1)

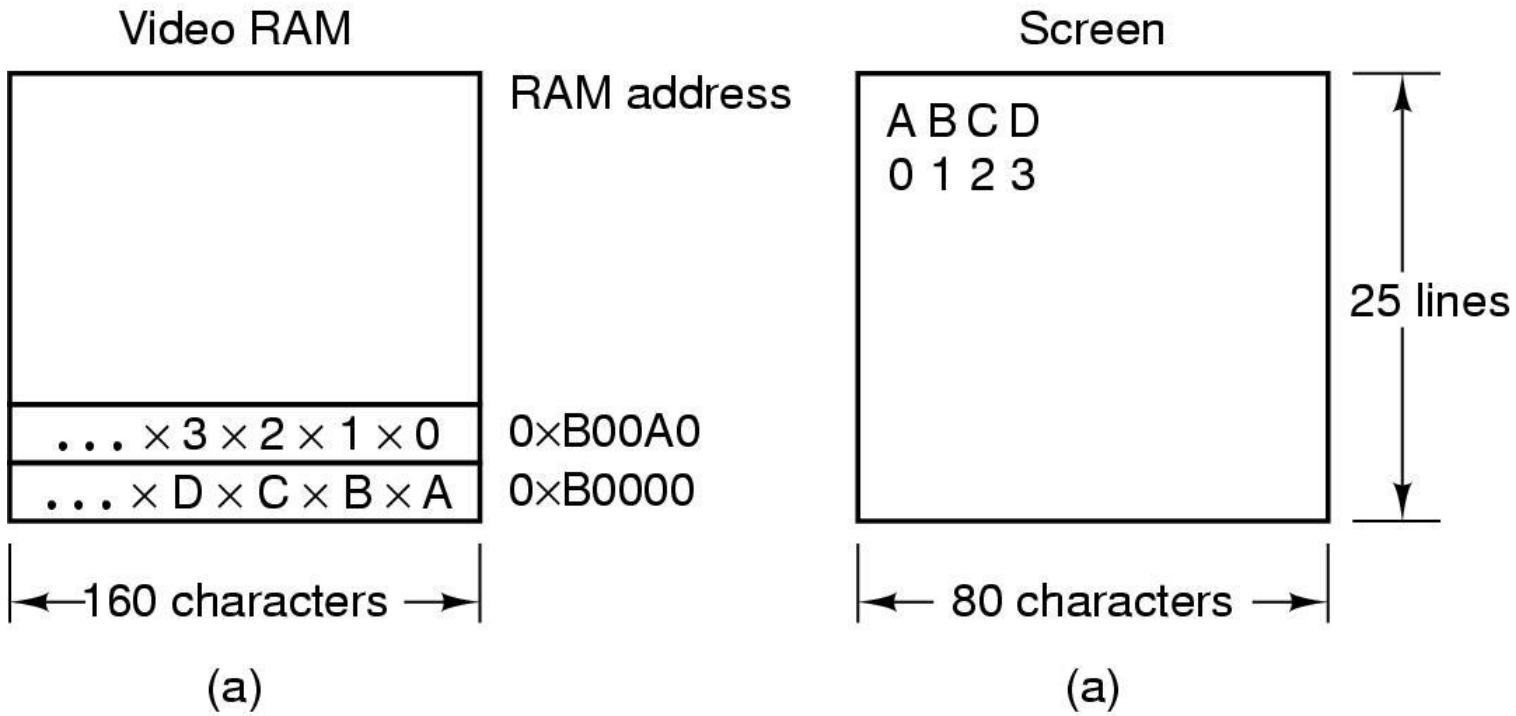
Memory-mapped displays

- driver writes directly into display's video RAM



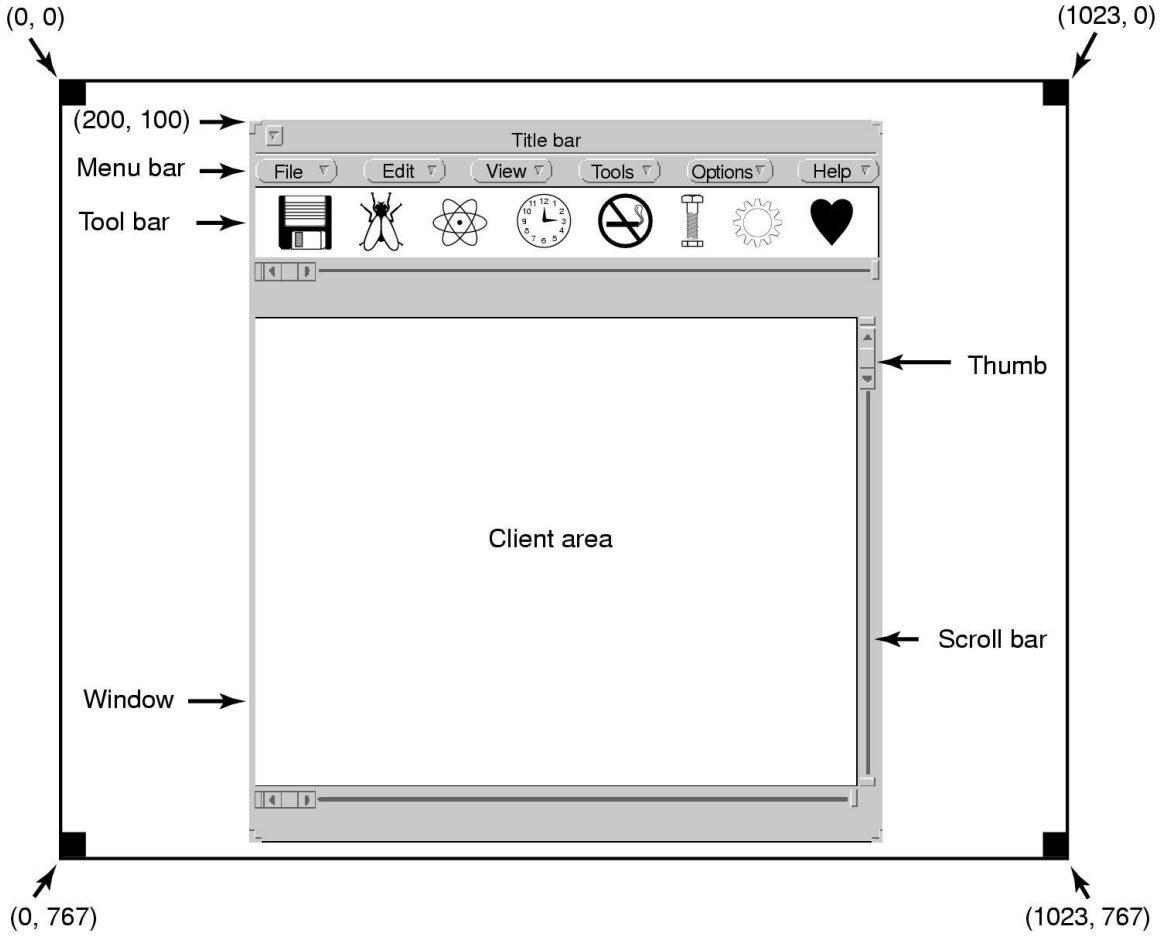
Display Hardware (2)

- A video RAM image
  - simple monochrome display
  - character mode
- Corresponding screen
  - the Xs are attribute bytes



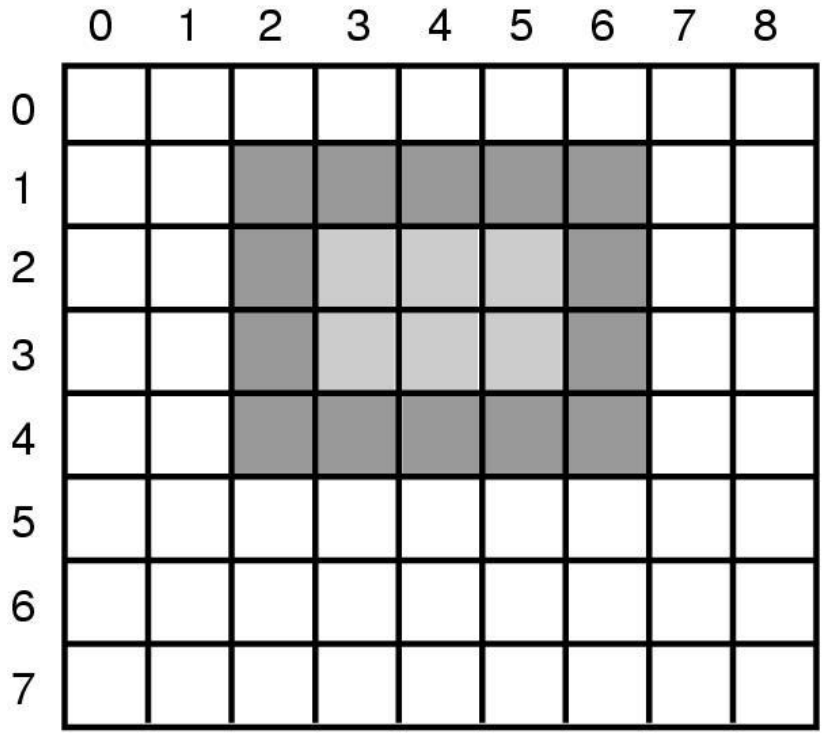
Output Software for Windows

Sample window located at (200,100) on XGA display



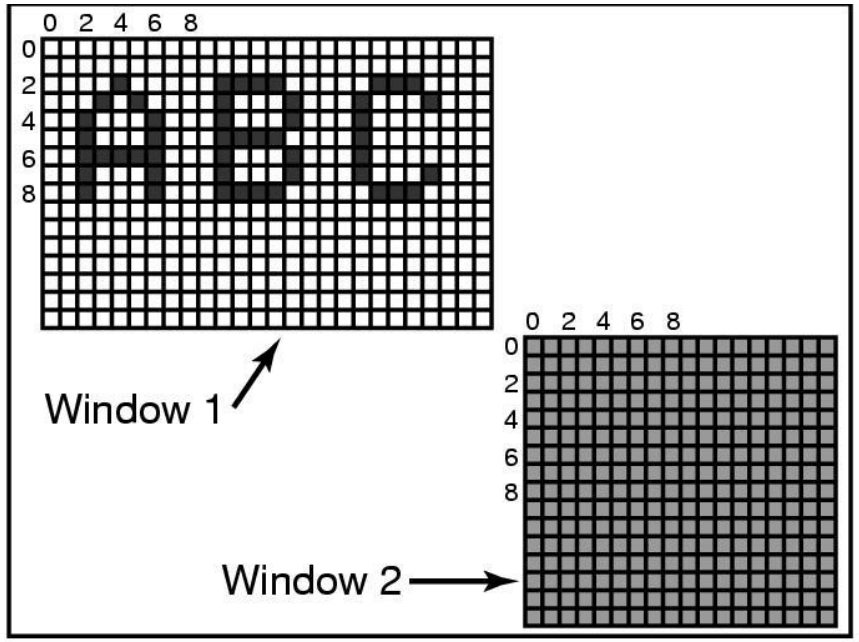
Output Software for Windows

An example rectangle drawn using *Rectangle*

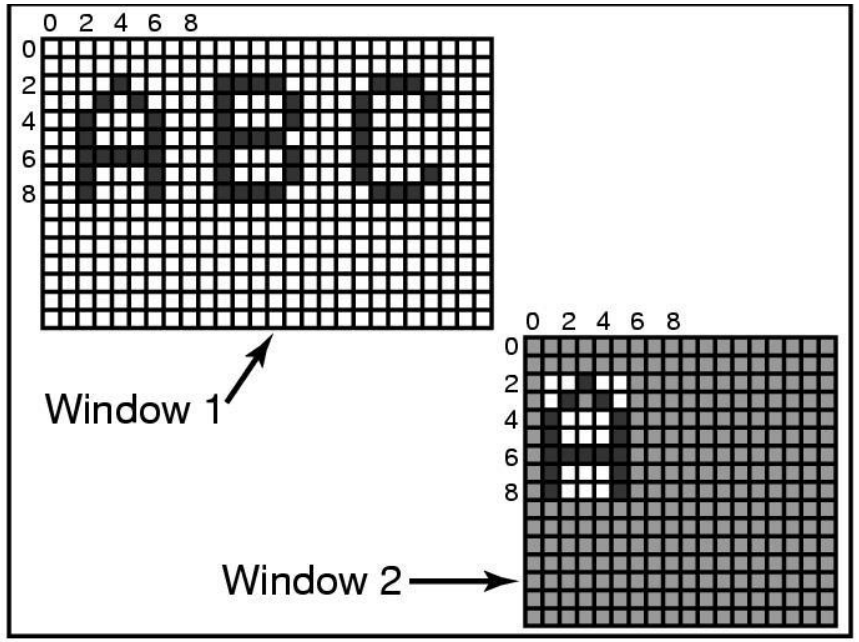


Output Software for Windows

- Copying bitmaps using *BitBlt*.
  - (a) before
  - (b) after



(a)



(b)

Output Software for Windows

Examples of character outlines at different point sizes

20 pt: abcdefgh

53 pt: abcdefgh

81 pt: abcdefgh

SUMMARY

- I/O hardware management
- I/O software management
- Disk management
- User Interface management