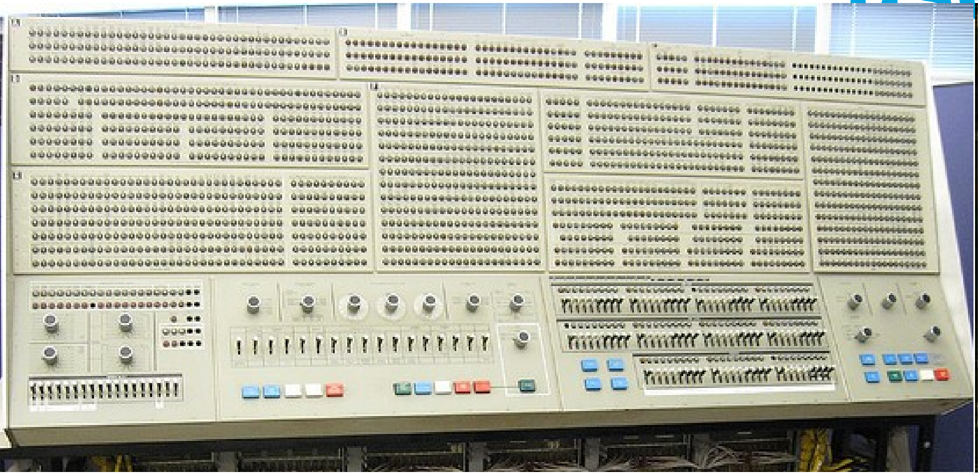
http://living-information.de/pdf/gui_history.pdf

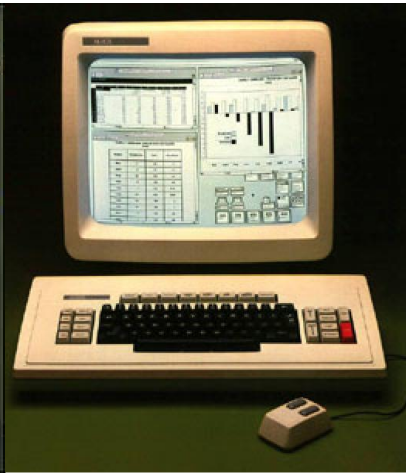
http://cs.iupui.edu/~cs265/spring06/slides/t03IntroToQt.ppt

Computer Graphics: Principles and Practice. Foley, van Dam, Feiner

First course of Computer Science

Part VII: GUI - Friendly Interface for users





Goals

- Know the advanced services provided by most OSs – GUI
  - The related IO devices
  - Mechanism
  - Architecture of UIMS – User Interface Management System

GO
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- GUI and its history
  - Punched cards, Switches, etc. (before)
  - Character terminal + Keyboard (1960s)
  - Raster display + **WIMP** (1980s)
    - **W**indow, **I**con, **M**enu, **P**ointing devices
  - Virtual Reality (future): 3D, Multimedia, et
    c.
- Mechanism of GUI devices
- Support from OS
- Complements

From **wikipedia** http://en.wikipedia.org/wiki/GUI

- A GUI uses a combination of technologies and devices to provide a platform that the user can interact with, for the tasks of gathering and producing information.
  - A series of elements conforming a visual language have evolved to represent information stored in computers. This makes it easier for people with few computer skills to work with and use computer software.
- The most common combination of such elements in GUIs is the WIMP ("**w**indow, **i**con, **m**enu, **p**ointing device") paradigm, especially in personal computers.
  - The WIMP style of interaction uses a virtual input device to control the position of a pointer and presents information organized in windows and represented with icons.
  - Available commands are compiled together in menus, and actions are performed making gestures with the pointing device. A
  - window manager facilitates the interactions between windows, applications, and the windowing system.
    - The windowing system handles hardware devices such as pointing devices and graphics hardware, as well as the positioning of the pointer.


Finder File Edit View Go Window Help
Mon 10:30 AM
Todd Taylor
Aki Shelton
Mark Brunst
Joslyn Smith
Judy Chin
Login Window...
Inbox
Delete
Reply
Forward
New
Junk
Get Mail
Search
From
Subject
Galen Stackwell
Greetings
Today
John Smith
Michelle
Ed Thompson
Mike
Juliette Walsh
Todd Taylor
Documents
Mac OS X Panther
Network
My Archives
iDisk
Home
Applications
Desktop
Pictures
Project folder
Project folder
Letters
Downloads
Stuff
Work in progress
Meeting notes
logo.jpg
Reports
Images in process
Adrien
Video Chat with Aki
20
motherboard_d...
motherboard_...
Thunder.v5.6.0...
NVIDIA_Geforc...
Office Excel 2007
Office PowerPoi...
Adobe Reader 8
Office Word 2007
DAEMON Tools
Thunder
Windows Media ...
Windows Update
beifen
Ghost
vista
WORKGROUP
Windows 激活
Windows 已激活
计算机名:
工作组:

GUI still follows "Dr. IPO"

- User controls contents, structure, and appearance of objects and their displayed images via rapid visual feedback
- Basic components of an interactive graphics system
  - **i**nput (e.g., mouse, tablet and stylus, force feedback device, scanner…)
  - **p**rocessing (and storage)
  - display/**o**utput (e.g., screen, paper-based printer, video recorder…)

PPTs from other\www.informatics.buu.ac.th_~kubola_975354Graphics\GraphicLect01_Introduction.ppt

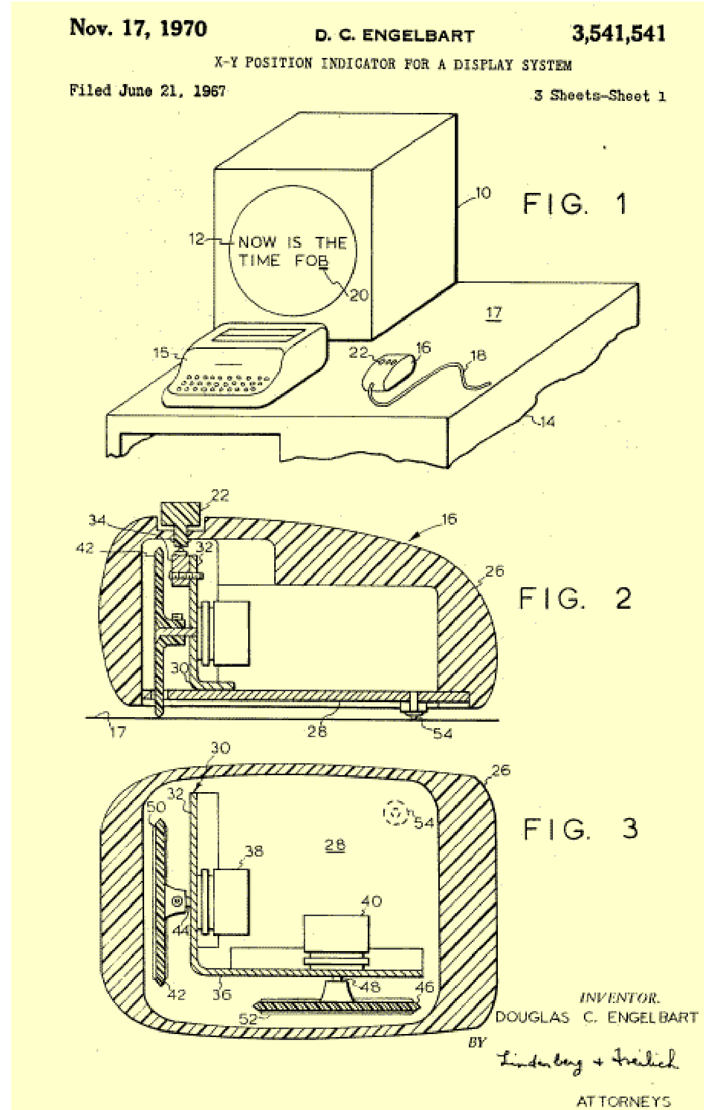
1950, Whirlwind Computer @ MIT

- The first digital computer capa
ble of displaying real time text
and graphics on a video termin
al
  - which at this time was a large **os
cilloscope screen**

- The Whirlwind was also the firs
t computer to use Core Memor
y for RAM, a storage method th
at flourished until the 1970's.
  - Core memory permanently store
s binary data on tiny donut shap
ed magnets strung together by a
wire grid.

GUI History

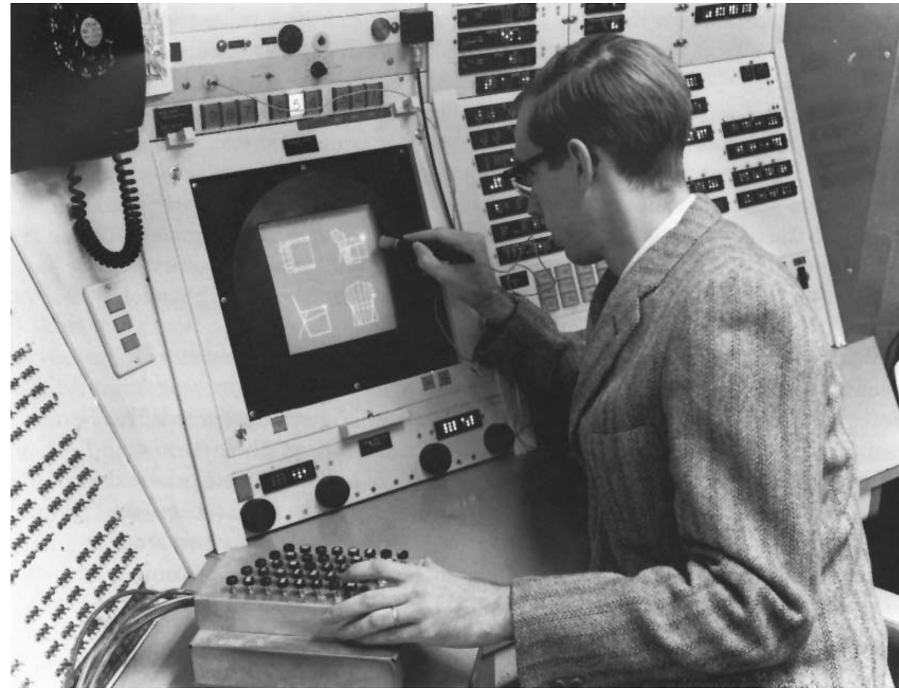
- In 1962, Douglas Engelbart invented the first "mouse," which he called an "X-Y Position Indicator."
- It was a little gizmo housed in a wooden box on wheels that moved around the desktop and took the cursor with it on the display.



Source: US Patent Office

GUI History

- In 1963 a grad stud ent at MIT, Ivan Sut herland, submitted as his thesis a progr am called "**Sketch pad**." This was the first GUI (Graphical User Interface) long before the term wa s coined."



http://accad.osu.edu/~waynec/history/images/ivan-sutherland

“Hall of Fame”

http://en.wikipedia.org/wiki/Xerox_Alt

http://en.wikipedia.org/wiki/Xerox_Sta

- In the 1970's, Xerox Labs developed **<u>Alto</u>** a nd **<u>STAR</u>** and introduced mouse pointing a nd selecting.
  - Xerox never successfully marketed their advan ces.
  - Apple and its Macintosh computer introduced t phical user ir nass market.

Xerox Alto

The Xerox Alto monitor has a portrait orientation.

Manufacturer	Xerox PARC
Release date	1973; 40 years ago
Units sold	2000
Media	2.5 MB single-platter cartridge
CPU	Bit-slice processor based on TI 74181
Memory	128-512 kB
Input	Keyboard, 3-button mouse, 5-key chord keyset
Related articles	Xerox Star; Apple Lisa, Macintosh

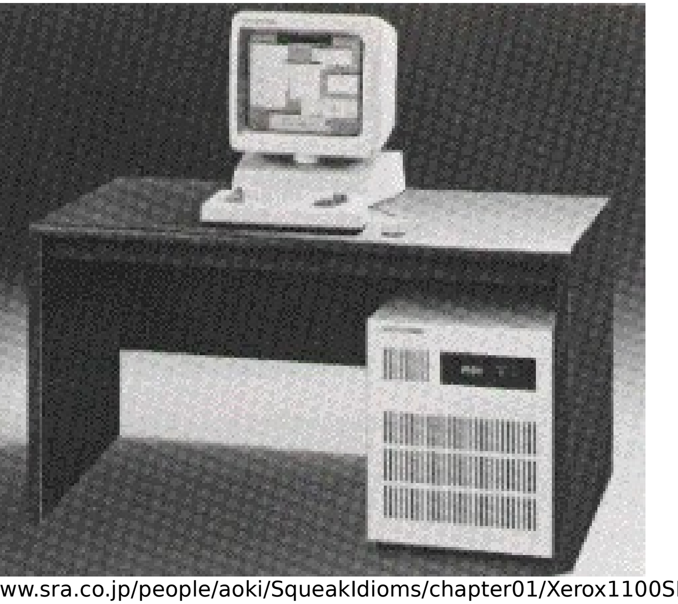
Xerox Star

Xerox Star 8010

Developer	Xerox
Manufacturer	Xerox
Type	Workstation
Connectivity	Ethernet

GUI History

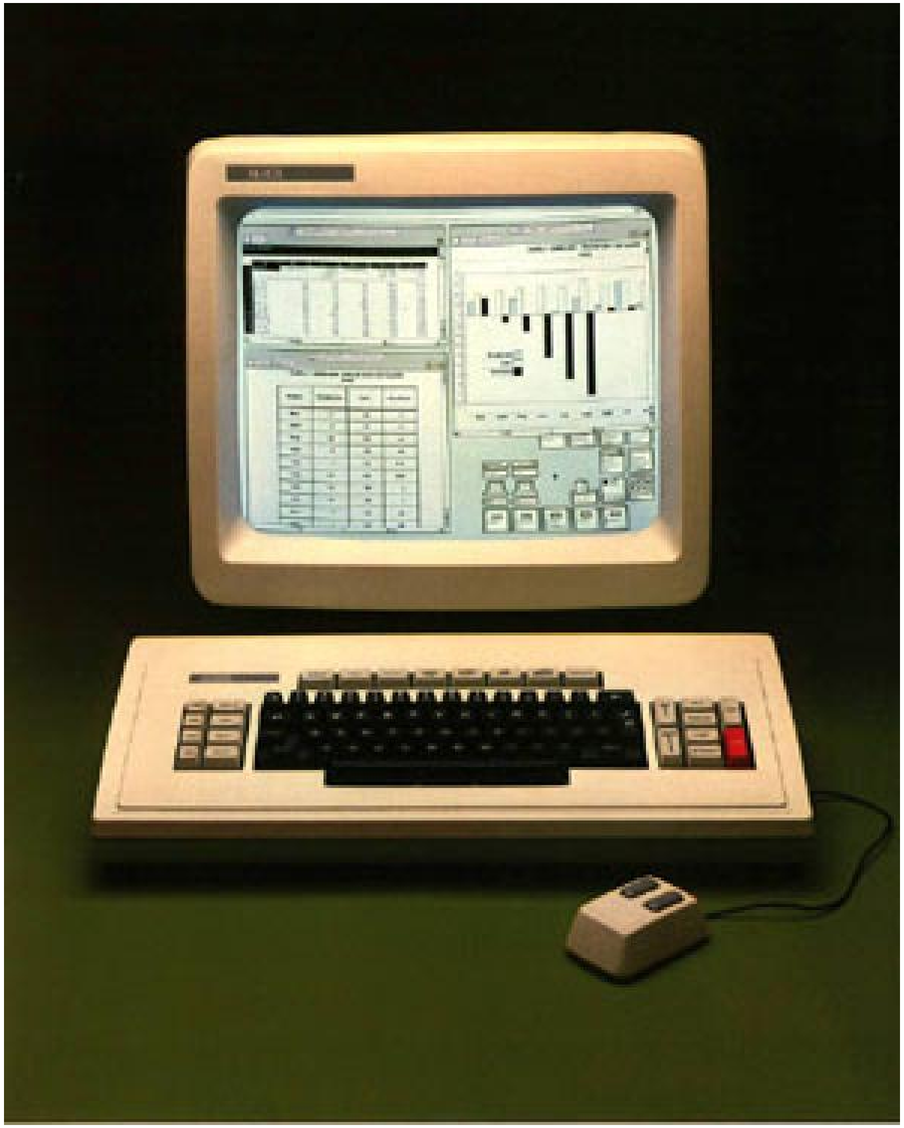
- In the 1970s, at Xerox's PARC facility, Alan Keys created an object-oriented graphical programming language called "Smalltalk." Smalltalk featured a graphical user interface (GUI) that looked suspiciously similar to later iterations from both Apple and Microsoft.



http://www.sra.co.jp/people/aoki/SqueakIdioms/chapter01/Xerox1100SIP.jpg

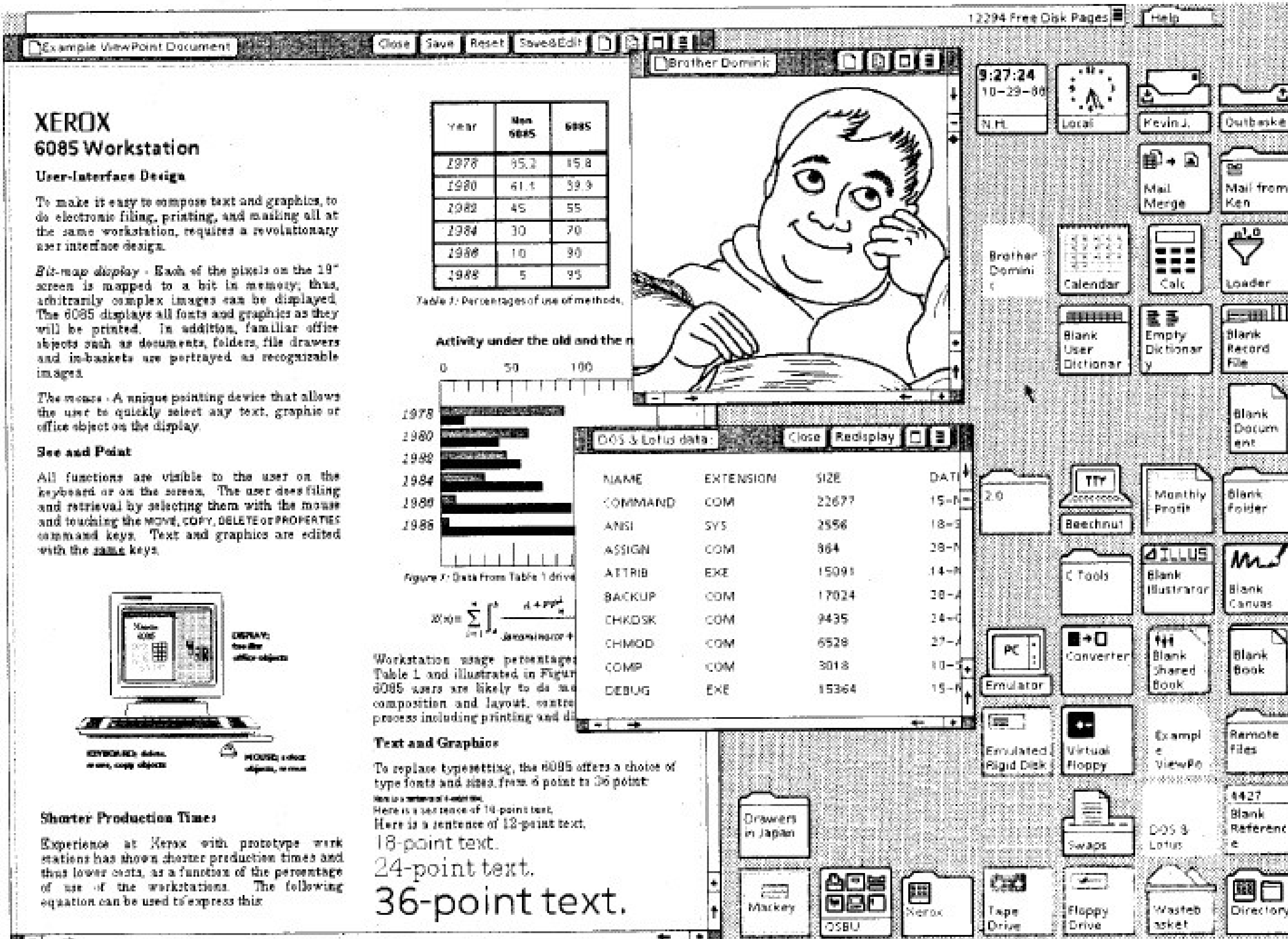
GUI History

- 1981, Xerox attempted to market the “Star.” It intr
oduced the idea of what y
ou see is what you get (WY
SIWYG).
- Commercial failure
  - cost ($15,000);
    - IBM had just announced a l
ess expensive machine
  - limited functionality
    - e.g., no spreadsheet
  - closed architecture,
    - 3rd party vendors could not add applications
  - perceived as slow
    - but really fast!
  - slavish adherence to direct manipulation



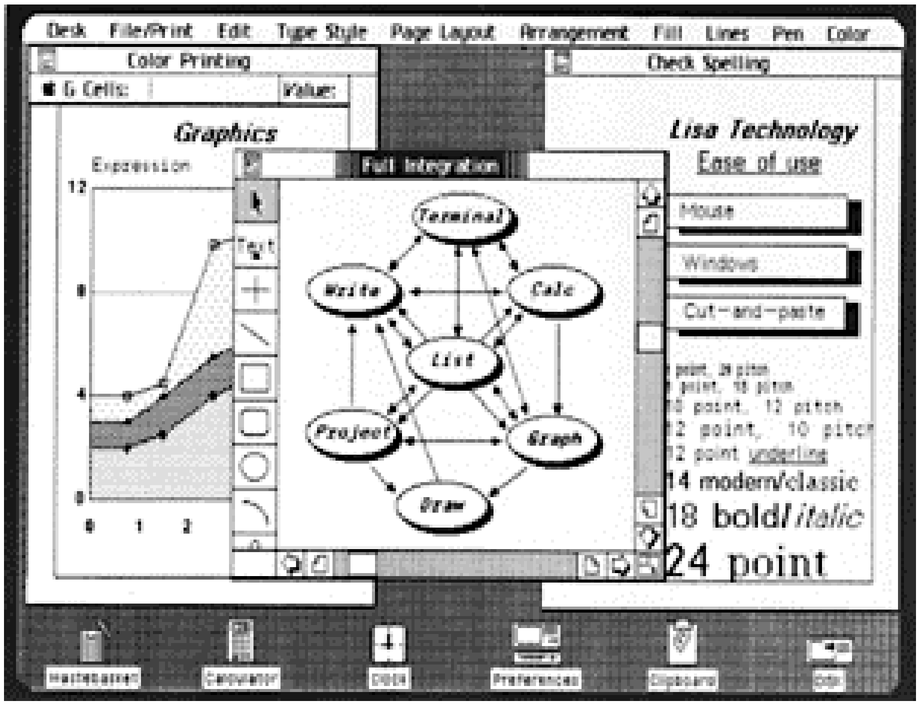
http://www.catb.org/~esr/writings/taouu/html/graphics/xerox_st

Screenshot of Xerox’s Star



Apple gets a GUI

- In 1983, the Apple Lisa was first GUI offering.



http://www.s-line.de/homepages/horber-privat/bilder/apple2a.jpg

Apple II, 1980

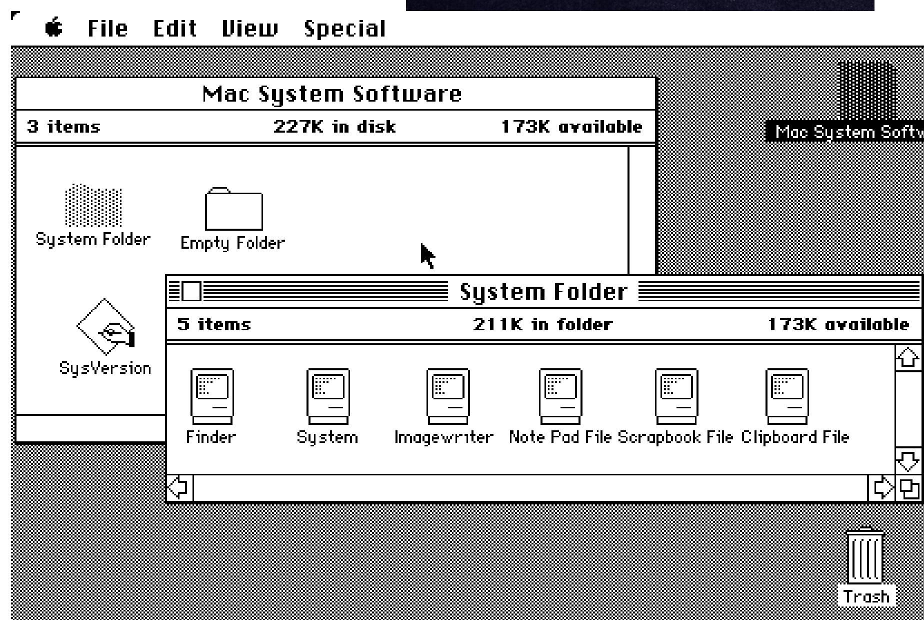
Lisa

http://fp3.antelecom.net/gcifu/applemuseum/lisa2.html

Apple gets a GUI

http://computermuseum.50megs.com/images/collection/apple-mac-pl

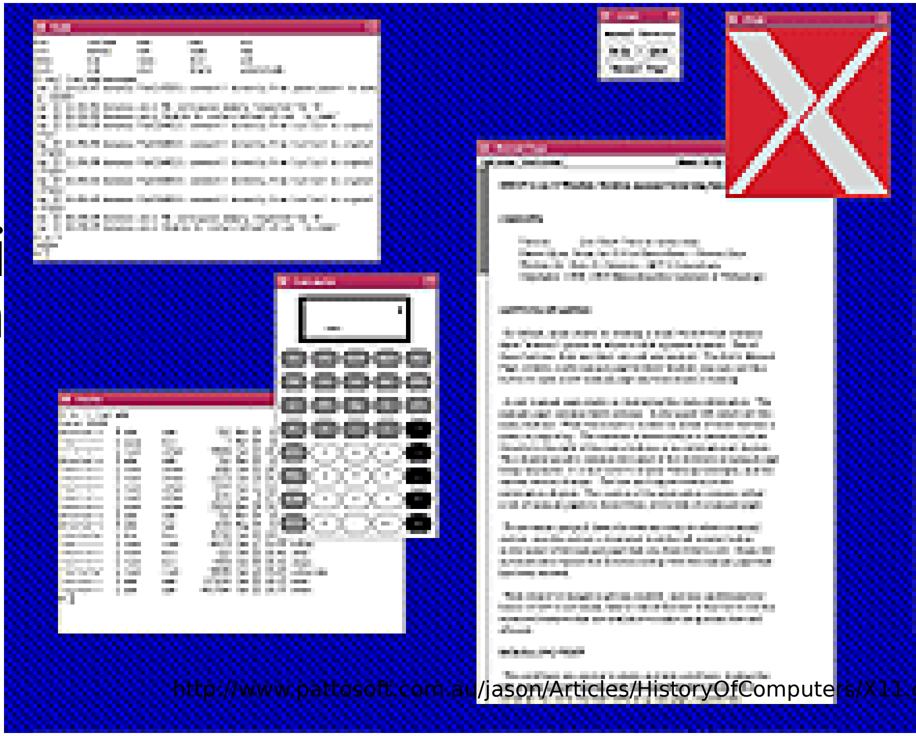
- In 1984, Macintosh was the first computer with a GUI marketed t o the masses.
  - “old ideas” but well done!
- Commercial success because:
  - aggressive pricing ($2500)
  - did not need to trail blaze
    - learned from mistakes of Lisa a nd corrected them; ideas now “mature”
    - market now ready for them
  - developer’ s toolkit encourage d 3rd party non-Apple software
  - interface guidelines encourage d consistency between applicat ions
  - domination in desktop publishi ng because of affordable laser printer
    and excellent graphics
  - Full Microsoft Office suite (Apple was the dominant playe



http://toastytech.com/guis/bigmac1.gif

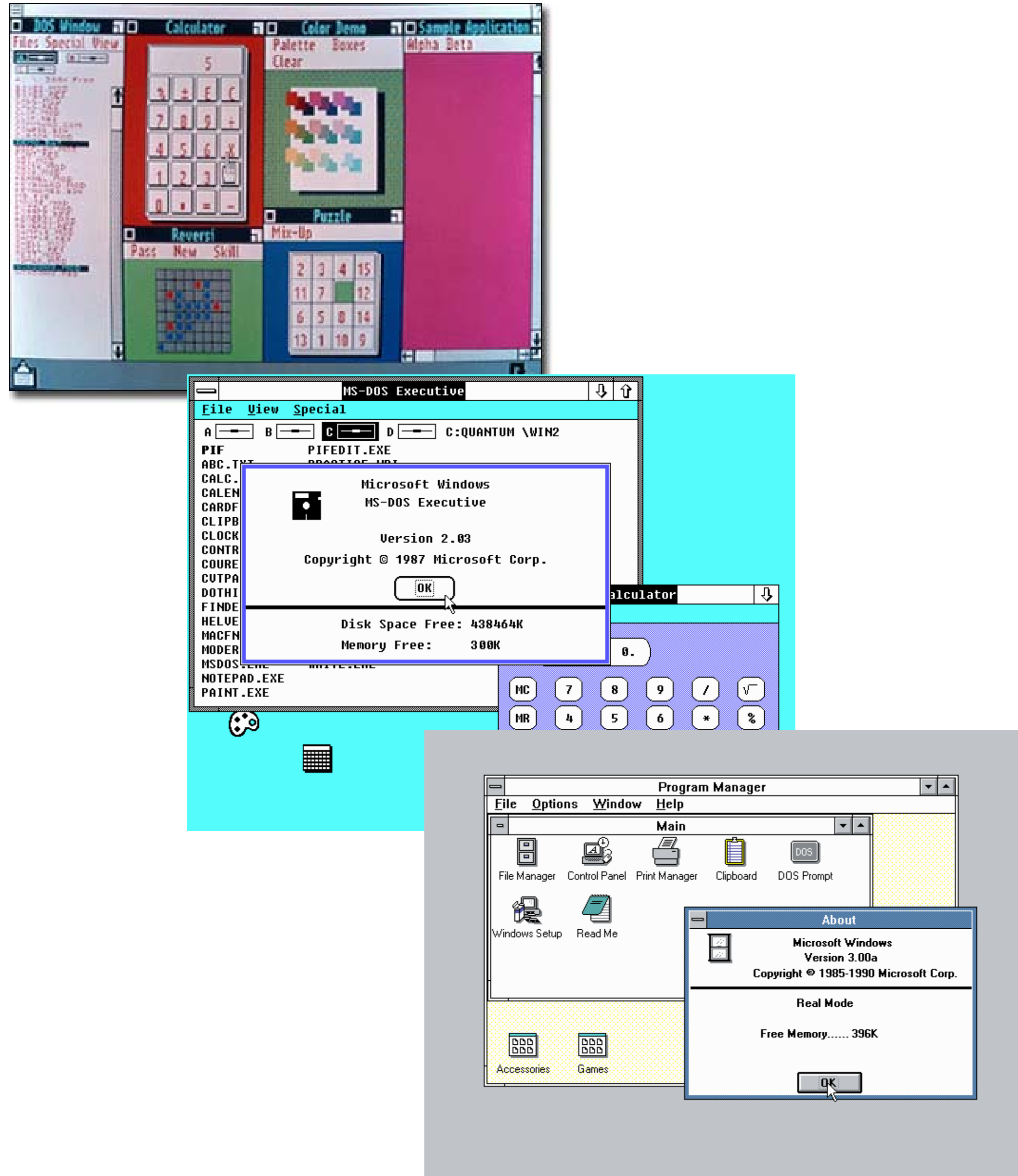
Unix Gets a GUI

- The X Windows System was introduced in the mid-1980s to provide graphical support for unix operating systems.
- The implementation was a client-server approach, where an X window system server ran on the displaying machine, and the client programs communicated with it using a network protocol.
- X provides only a communication *mechanism, not policy*. At least three major user interface look & feel styles are widely used on X - MIT's own Athena style, Sun and AT&T's OpenLook, and OSF's Motif (supported primarily by HP and IBM)



Microsoft Gets a GUI

- Microsoft introduced Windows 1.0 in 1985
  - Tiled Windows, no overlapping
- Windows 2.03 in 1987
  - Overlapping windows
- Windows 3.0 in 1990
  - Features Program Manager

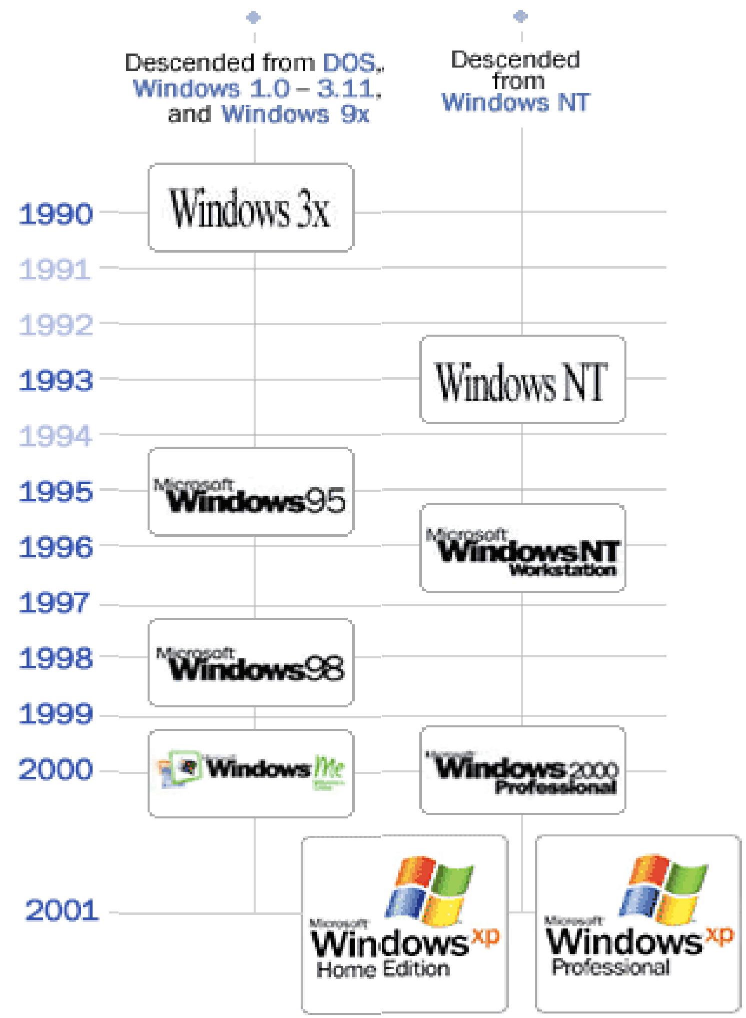


Shells

- Unix and DOS operating systems circa 1980s do suppo rt text-based user interfaces via a program called a she ll. These shells insert another layer between the user and the operating system. Typical text shells under uni x are csh and ksh. The typical text shell under microso ft is command.com. It is still emulated today by cmd.e xe.
- Original unix and Microsoft GUI support was also impl emented as shells. The dominant unix GUI library bec ame an open library called X11 supported by the X.org foundation. Microsoft introduced Windows 1.0 as a sh ell that ran on a layer above MS-DOS.
- The original Apple GUI is embedded into its operating system kernel. Windows migrated to embedding GUI s upport beginning with Windows NT.

Windows Timeline

- It took roughly 15 years to consolid ate its shell-base d GUI architectur e offerings with it s embedded GUI architecture offer ings.



http://www.microsoft.com/windows/WinHistoryProGraphic.mspx

Now: Graphics for the masses!

What enabled the sudden shift?

Chief hardware advances:

1. Cheap RAM
   – graphics buffers are memory hogs
2. Success of raster graphics (vs. vector)
   – display (CRT) could be like cheap TV
3. Fast, cheap CPUs
   – calculations for drawing & rendering fonts

All thanks to integrated circuit technology!

GO
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e

- GUI and its history
- Mechanism of GUI devices
  - **Composing figures** in VC’ s Memory, and **Painting dots** on Raster display
- Support from OS
- Complements

Computer graphic system

- 5 major elements
  - Processor/CPU
  - Memory
  - Frame buffer
  - Input devices
  - Output Devices

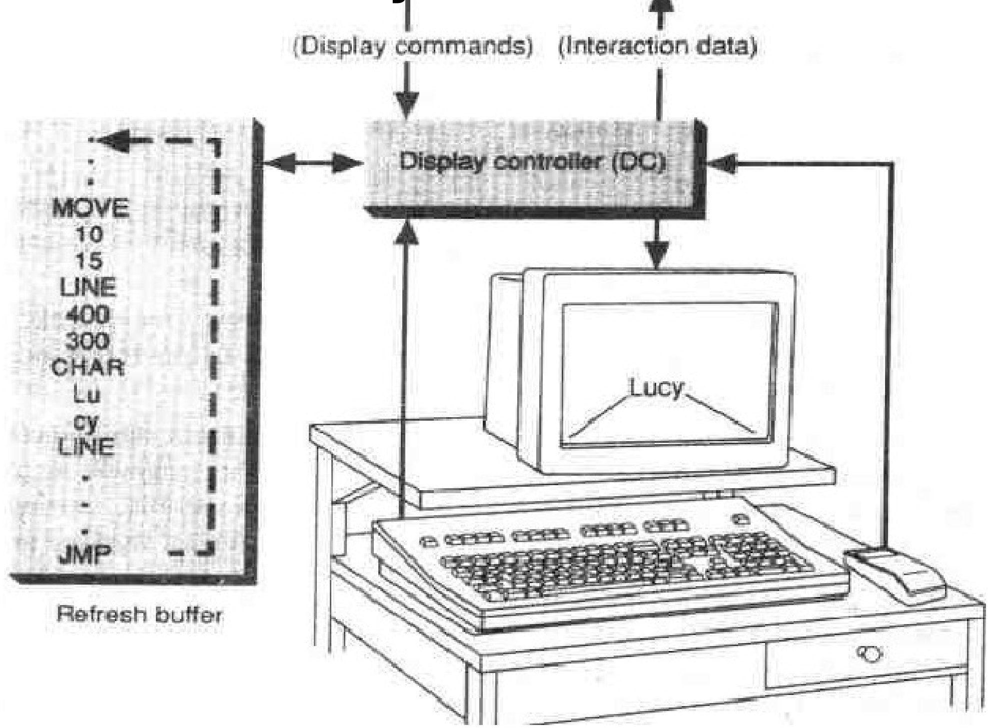
Res-GUI\02_GraphicDevices.ppt

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

Mechanism of GUI devices

- 1966 ~ 1980
- Vector display
  - The display devices deve loped in mid-sixties and i n common use until the mid-eighties are called v ector, stroke, line drawin g or calligrpahic display.
  - Term vector is used as a s ynonym for line here; a st roke is a short line, and c haracters are made of se quences of such strokes

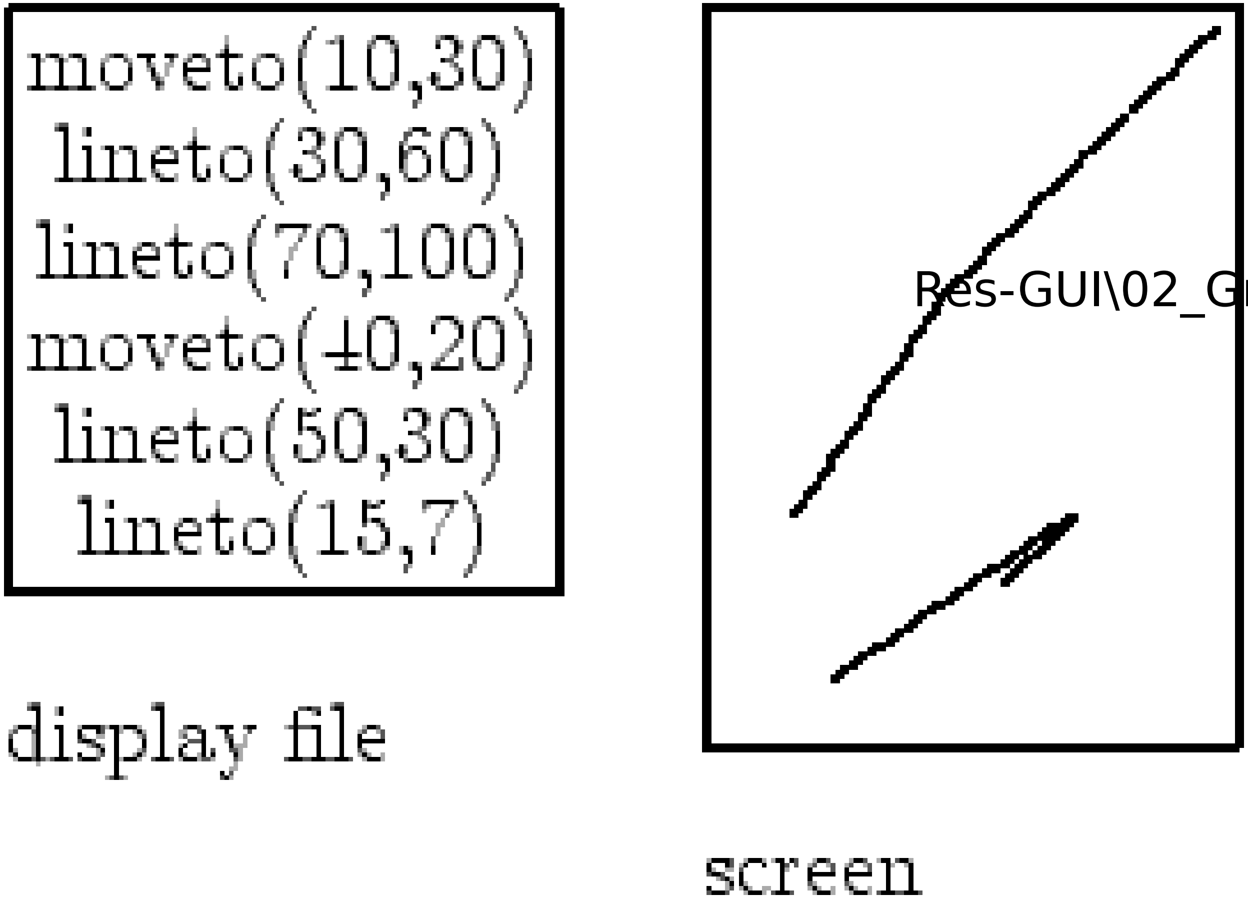
A typical vector system consists of a **display processor** (connected as an IO peripheral to CPU), a **display buffer memory**, and a **CRT**



The buffer stores the computer-produced display list or display program; it contains point- and line-plotting commands with (x, y) or (x, y, z) endpoint coordinates, as well as

- Calligraphic Displays Res-GUI\02_GraphicDevices.p
  - also called vector, stroke or line drawing gra phics
  - lines drawn directly on phosphor
    - display processor directs electron beam accordi ng to list of lines defined in a "**display list** “
    - phosphors glow for only a few micro-seconds so lines must be redrawn or **refreshed** constantly
    - deflection speed limits # of lines that can be dra wn without flicker.

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt



Res-GUI\02_GraphicDevices.p

- Images are described in terms of line segments rather than pixels.
- Display processor cycles through the commands

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

Also 1960s - DVST Direct View Storage Tube 直观存贮显象管

- The commands for plotting points, lines, and characters are interpreted by the display processor.
- It sends digital and point coordinates to a vector generator that converts the digital coordinate values to **analog voltages** for beam-deflection circuits that displace an electron beam writing on CRT's phosphor coating

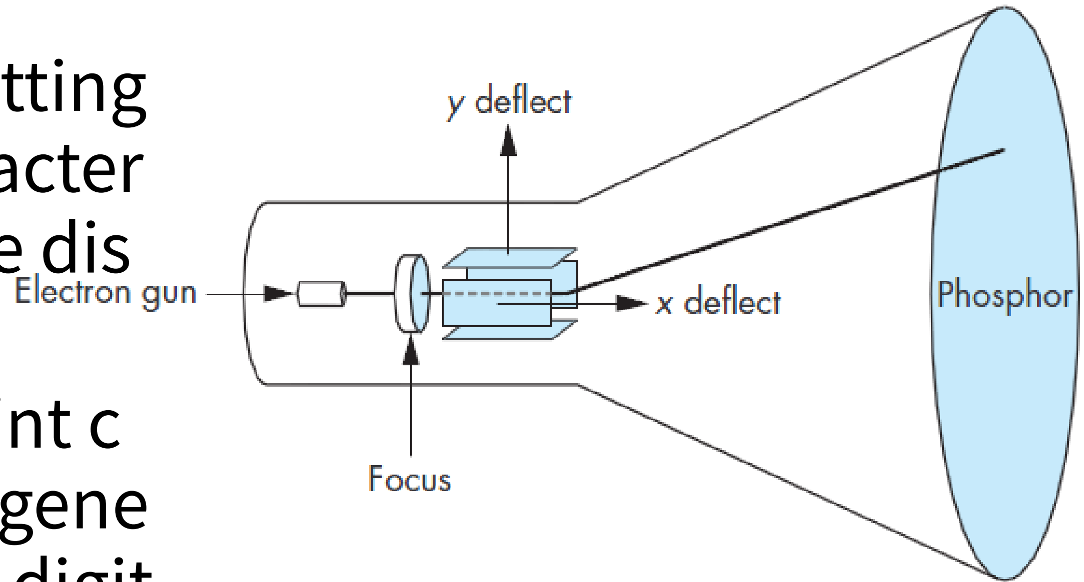
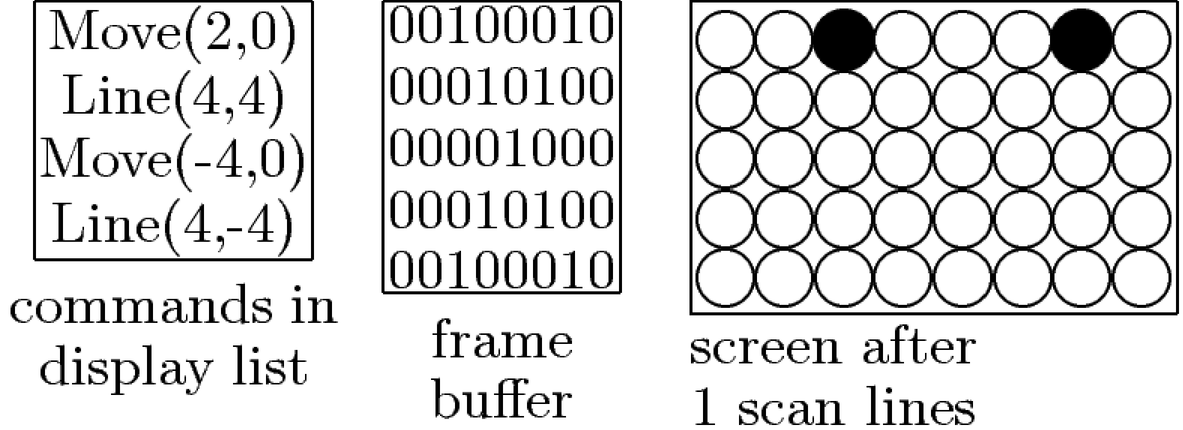
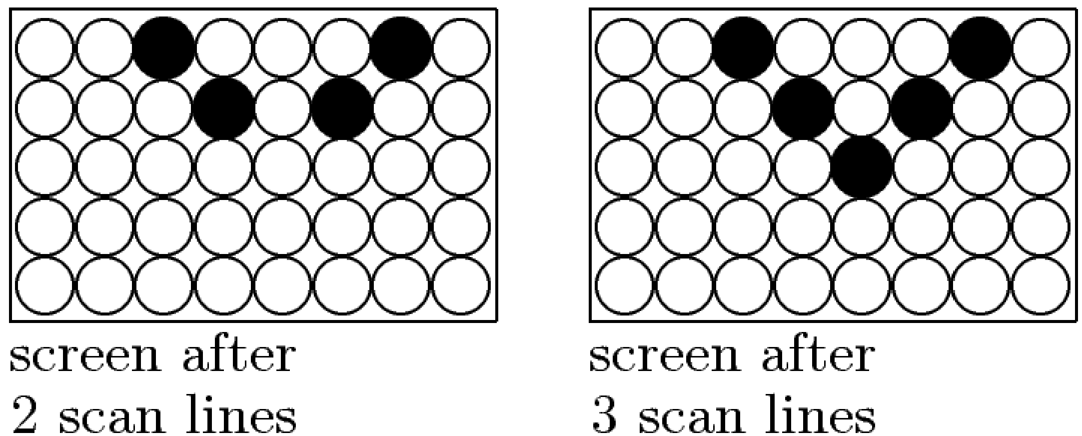


FIGURE 1.3 The cathode-ray tube (CRT).

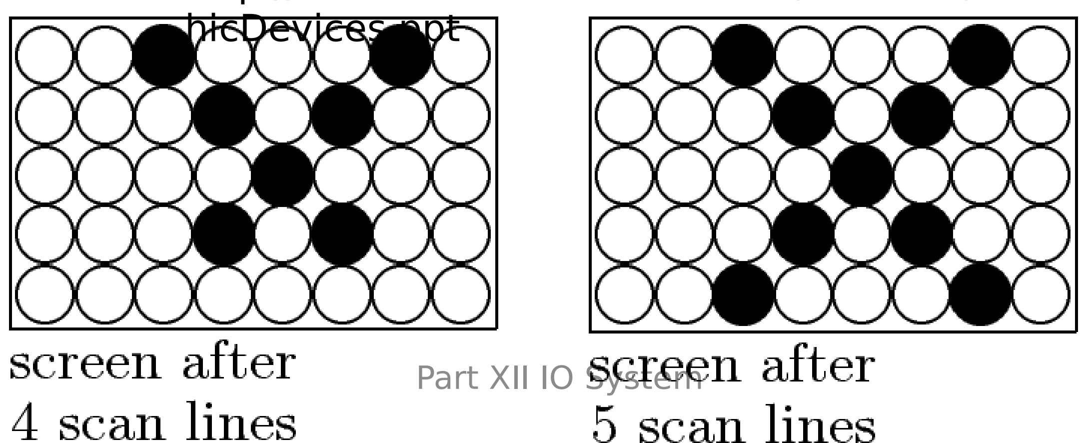
- Raster Display [栅格显示器]
  - Display **primitives** (lines, shaded regions, characters) stored as pixels in **refresh buffer** (or **frame buffer**)
  - Electron beam scans a regular pattern of horizontal raster lines connected by horizontal retraces and vertical retrace
  - Video controller coordinates the repeated scanning
  - Pixels are individual dots on a raster line

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt



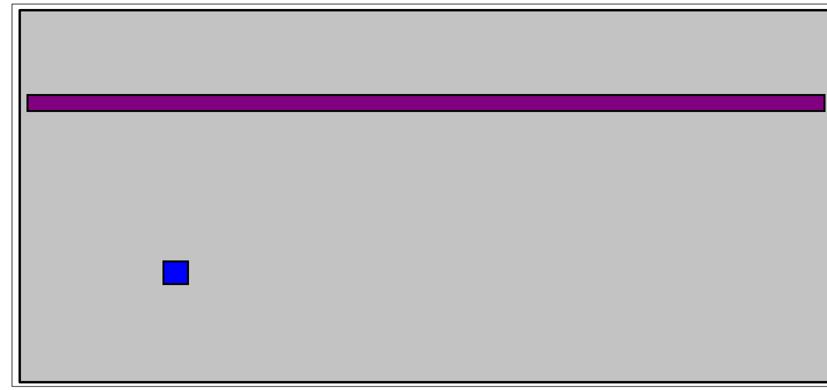


http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt



Basic Definitions

- Raster: A rectangular array of points or dots.
- Pixel (Pel): One dot or picture element of the raster
- Scan line: A row of pixels

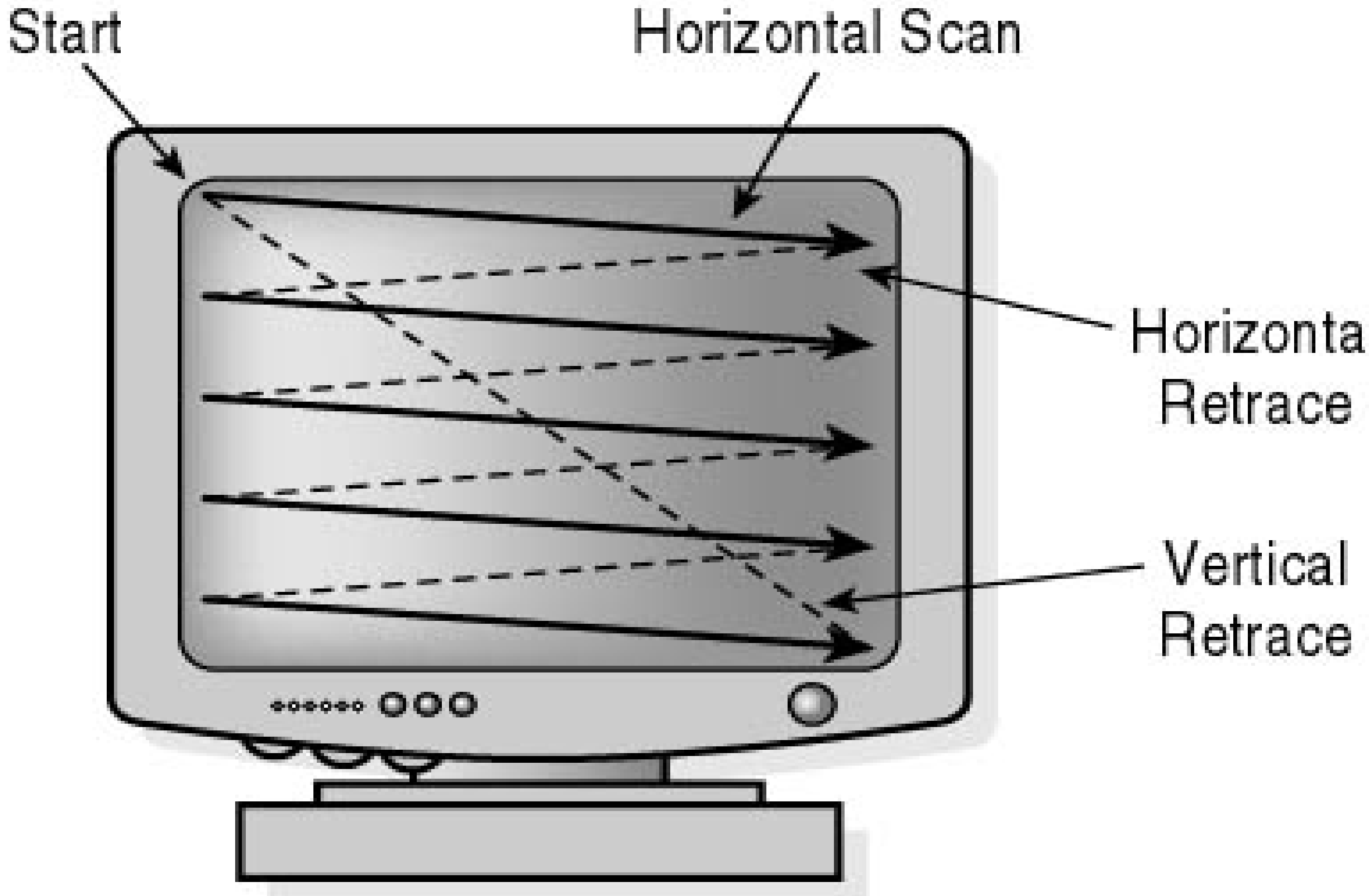


Video raster devices display an image by sequentially drawing out the pixels of the scan lines that form the raster.

http://www.informatics.buu.ac.th/~kubo.a/310355/Lectures/02_GraphicDevices.ppt

Refresh Rates and Bandwidth

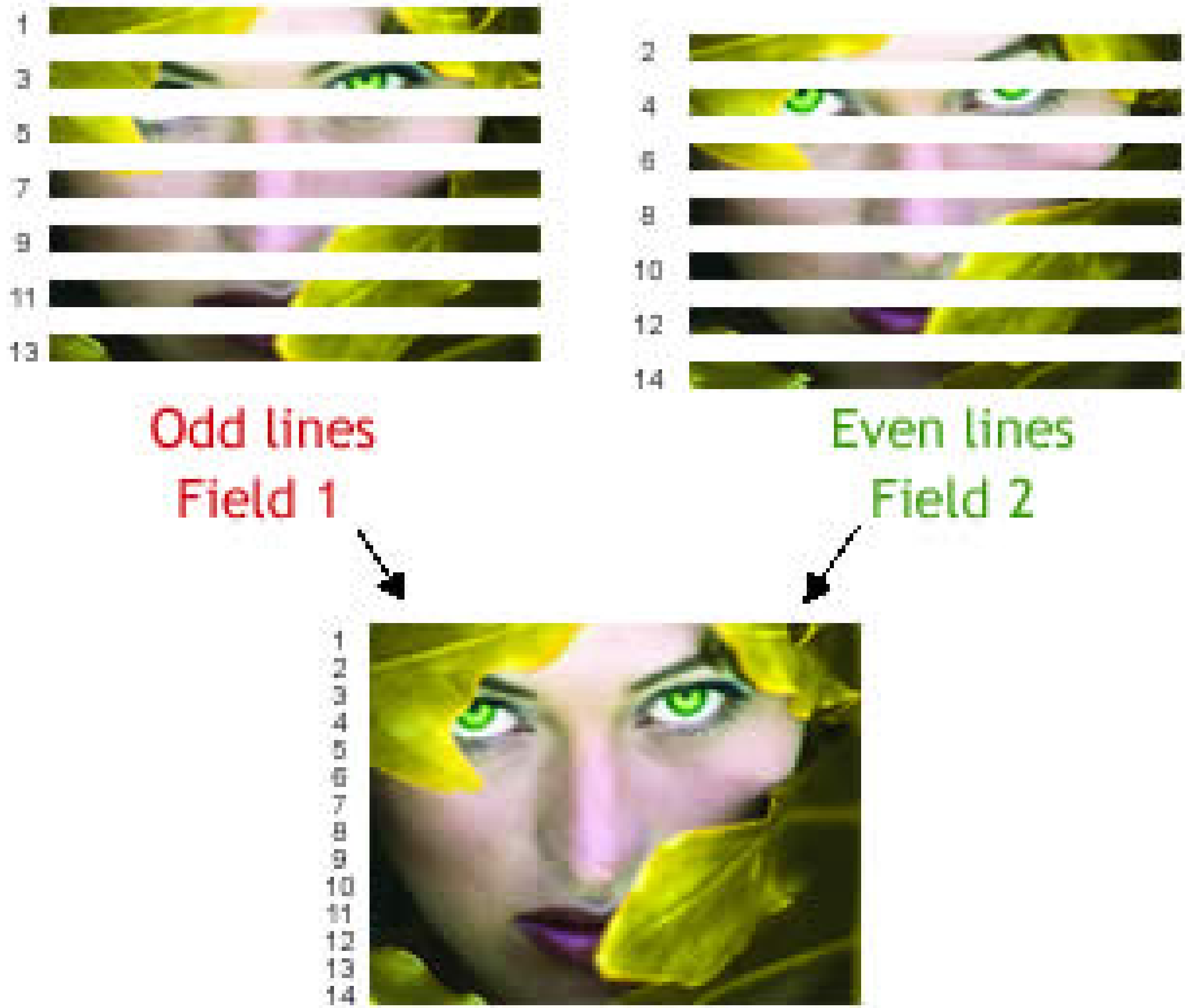
- Frames per second (FPS)
- TV (interlaced) 30 FPS x 1/4 = 8 MB/s



CRT Sweeping

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

Interlaced



Field 1 + Field 2 = Frame (complete image)

Display Rate: 60 fields per second (North America)

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

Then, new architecture for GUI

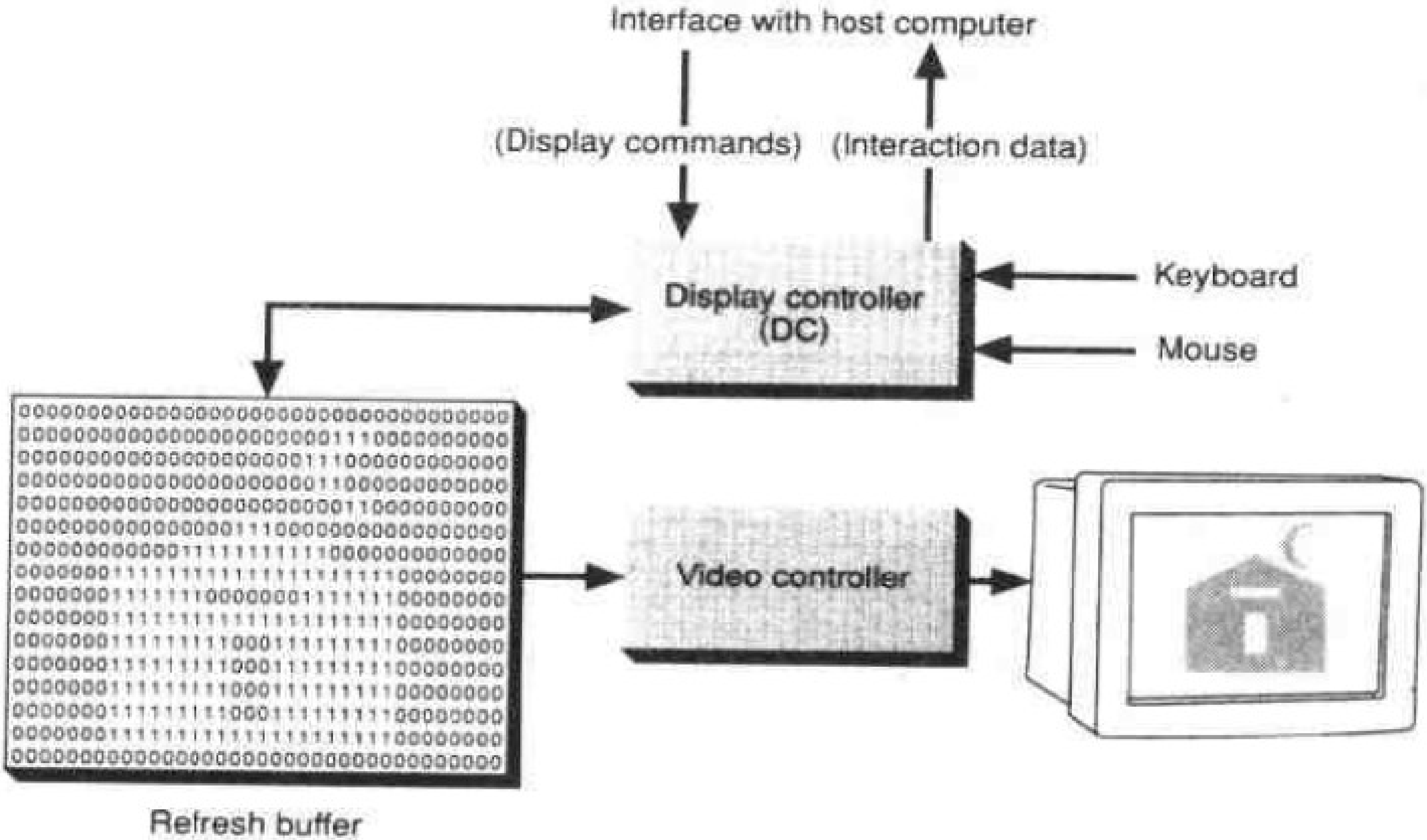
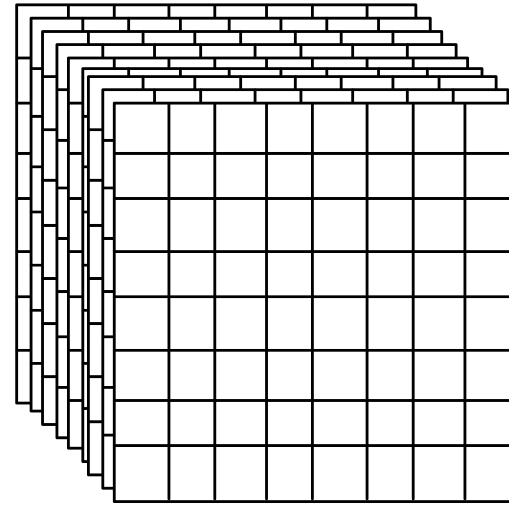


Fig. 1.2 Architecture of a raster display.

Frame Buffer

- A frame buffer is charac terized by size, x, y, and pixel depth.
- the **resolution** of a fra me buffer is the numbe r of pixels in the display . e.g. 1024x1024 pixels.
- Bit Planes or Bit Depth i s the number of bits cor responding to each pix el. This determines the **color resolution** of the buffer.



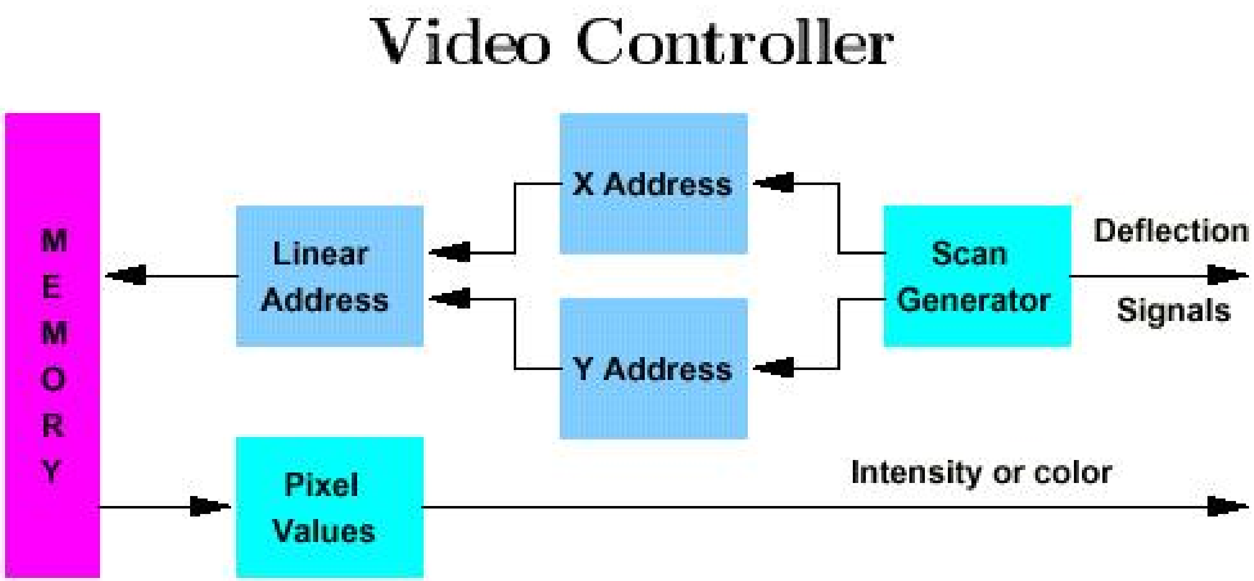
Bilevel or **monochrome** displays have 1 bit/pixel

8bits/pixel -> 256 simultaneous colors

24bits/pixel -> 16 million simultaneous colors

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

Video Controller



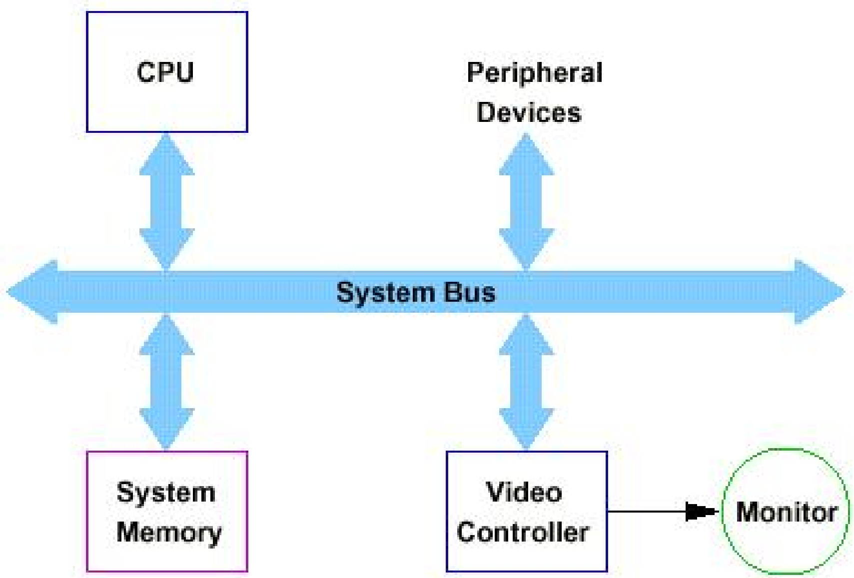
- Problems with memory access { 50 ns pixel time (480 x 64 0 x 60 Hz) is shorter than typical 200 ns RAM cycle time.
- - Must fetch multiple pixels per access.
- - Can eat up a lot of memory bandwidth.
- - Can eat up a lot of main bus bandwidth if so organized.

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

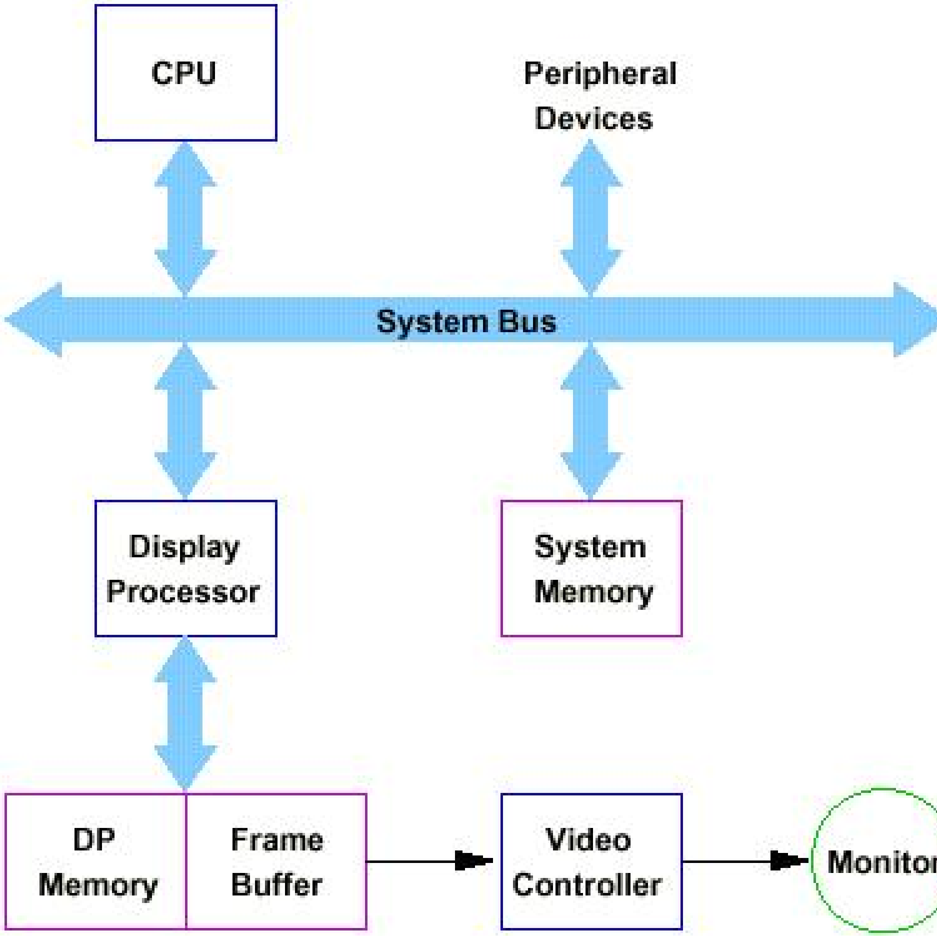
Simple Raster systems

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

- No special graphics processing except video controller. Two basic frame-buffer mappings.
- Single ported frame buffer
- Passes video information over system bus.
- Simple and flexible.
- Probler … l.



- Graphics processor has its local memory and manages the frame buffer and specialized graphics programs.
- Typical architecture for "plug in" graphics cards.

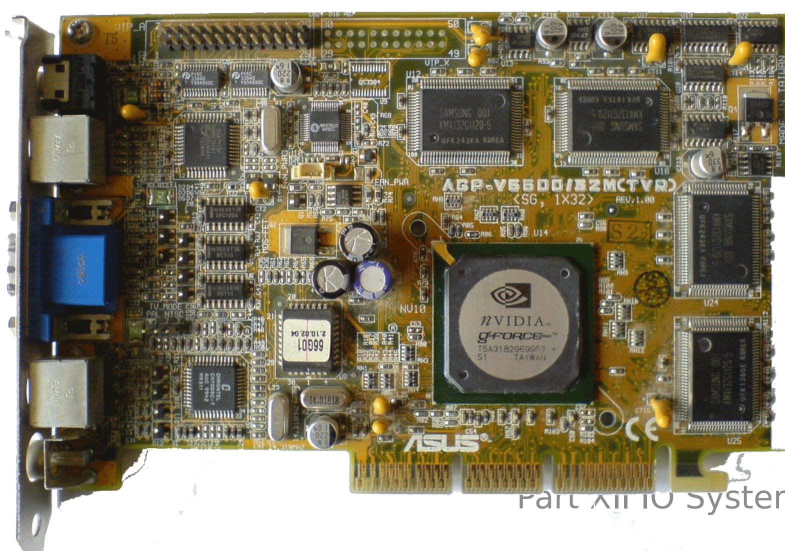


http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

Example: GeForce 256

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

- Released in 1999.
- One chip solution; 2D and 3D support. 2D includes MPEG-2 (DVD) decoder.
- RAM from 32MB-128MB
- GeForce GPU (graphics processing unit) has 23 million transistors ... more than Intel PIII.



GO
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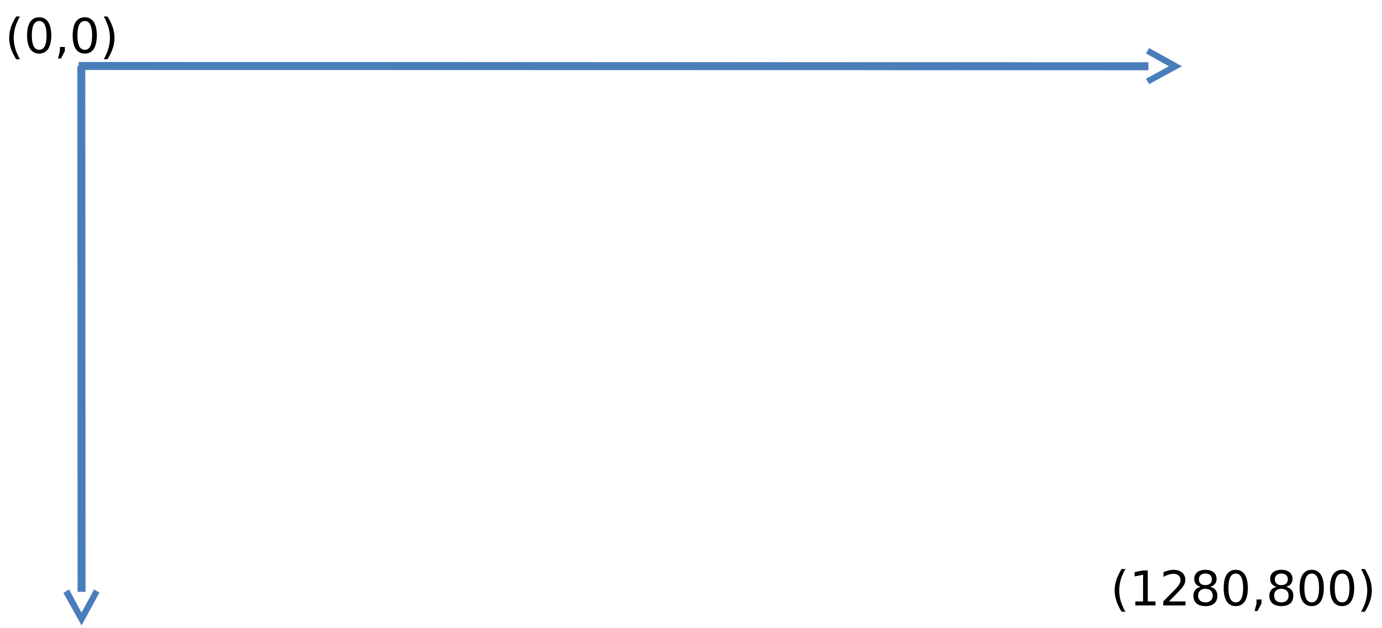
- GUI and its history
- Mechanism of GUI devices
- Support from OS
  - Based on Device management
  - A special course named "**C**omputer **G**raphics"
  - Interactions are based on event driven programs
- Complements

Logic of GUI

- With the VC (of course its drivers), GUI could be seen as a region you can draw pictures
  - It first defines a **DESKTOP** area – the display region, but with coordinate different from Cartesian coordinate
  - Figures are put into VC's memory, the controller then show them in the display – CRT, LED, …

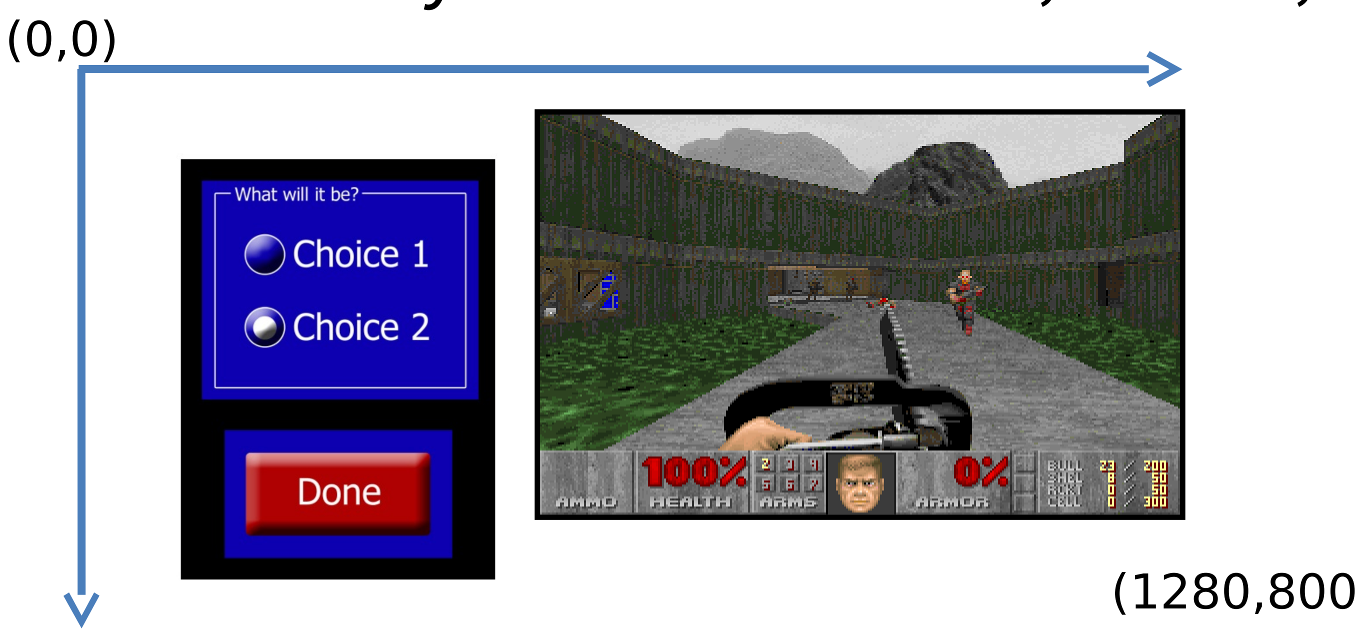


Logic of GUI

http://en.wikipedia.org/wiki/PHIG

- Beyond VC, there is another layer to provide **G**raphic **O**utput **P**rimitives (line, arc, region, …) defined in some standard **GSS** (Graphic Support Software)
  - There are many standards – GKS, PHIGS, CGI

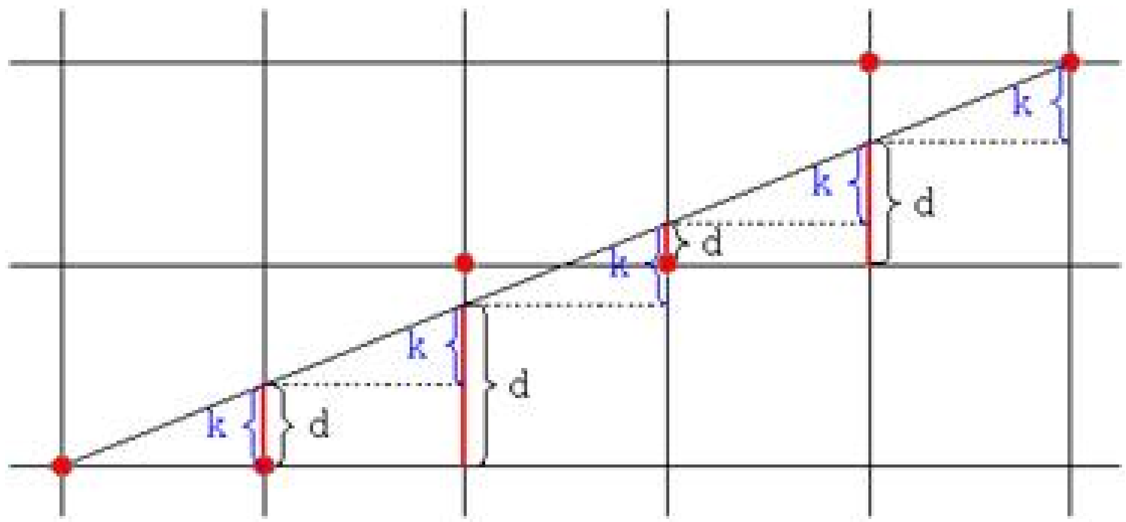
Graphics Kernel System 计算机图形核心系
Programmer's Hierarchical Interactive Graphics System, 程序员层次交互图形
Computer Graphics Interface 计算机图形接
系统

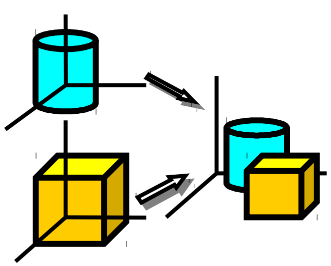


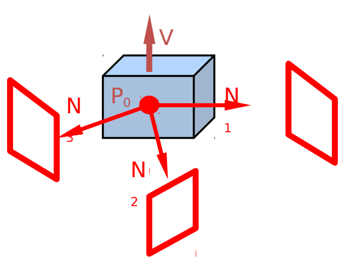
http://www.geog.ucsb.edu/~kclarke/G128/Lectur

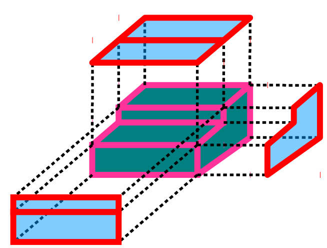
- A special course named Computer Graphics (CG), which aims to consider how to represent figures

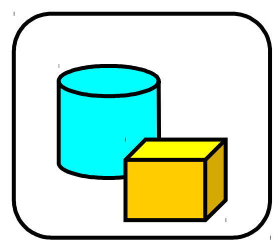
How to draw lines by using dots?











How to represent 2-/3-D by transformations?

Logic of GUI

- Similar with the relationship between basic data type (int, char) and compound data type (struct, union), it' s convenient to provide higher abstraction based on primitives, that is the GUI components – WIMP
  - Called Graphic Application Software, like OpenGL, DirectX

- The most important type of graph we use is a tree. A (connected) tree is a directed graph without closed paths or loops.

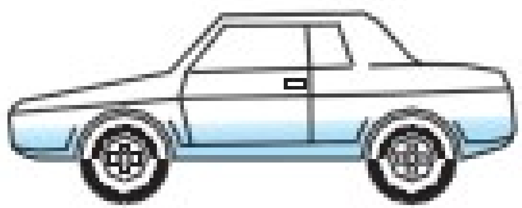


FIGURE 8.4 Automobile model.

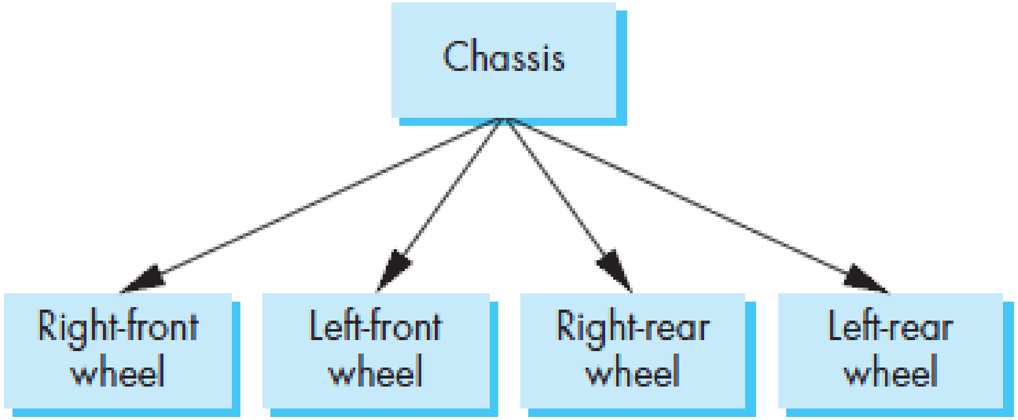


FIGURE 8.6 Tree structure for an automobile.

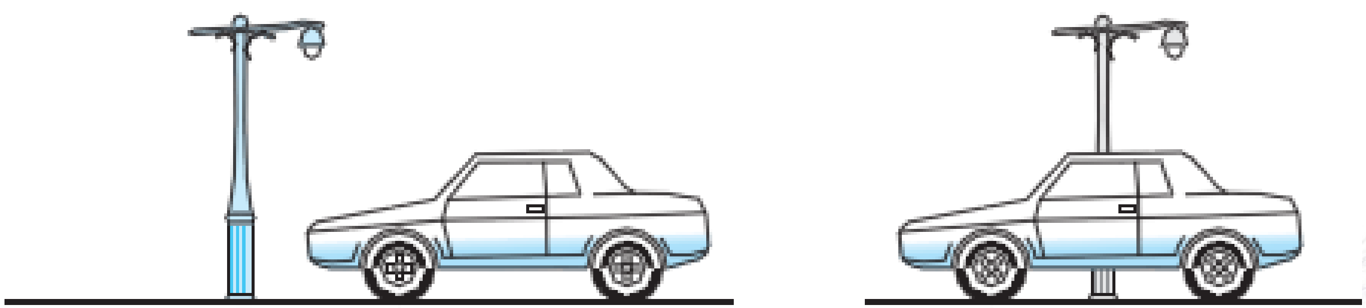
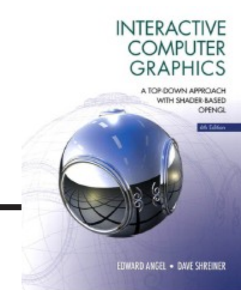
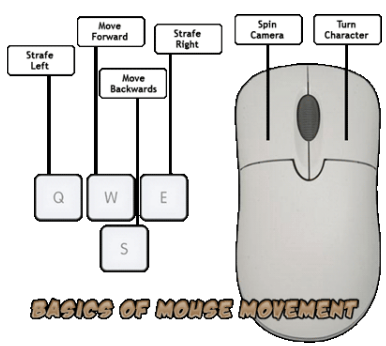


FIGURE 8.5 Two frames of animation.



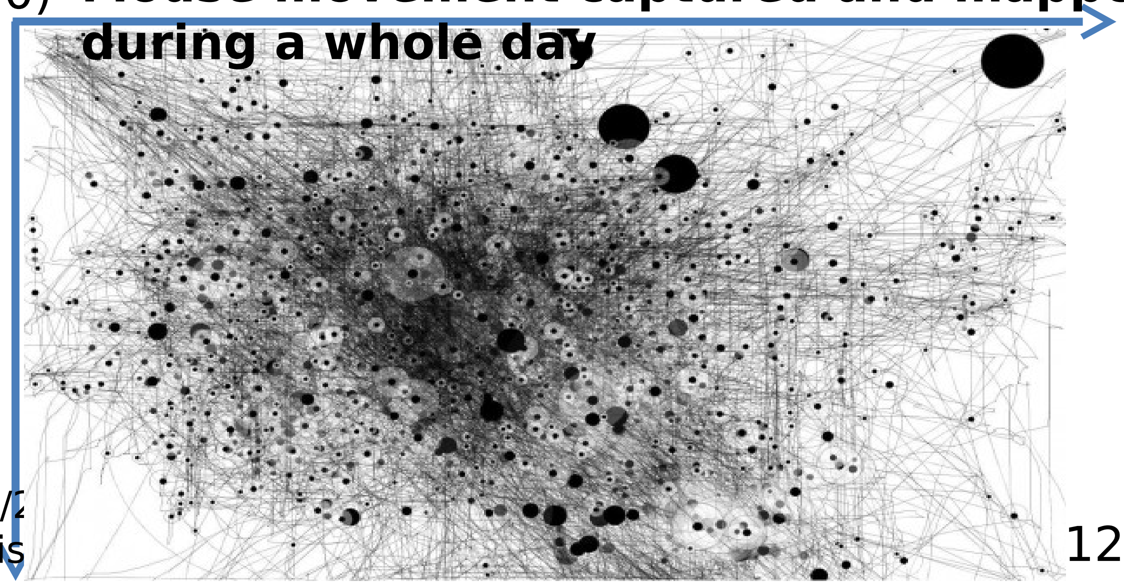
Logic of GUI

- With **INTERRUPT**, OS can capture the position of your mouse as well as the input from keyboard, and then send messages to combine position with functions connected with GUI components
  - This is called **event driven** mechanism



http://aggronaut.com/2
07/keyboard-turning-is
your-raid/

(0,0) **Mouse movement captured and mapped during a whole day**



1280,800)

http://www.artlayer.com/mouse-movement-screen-mapping

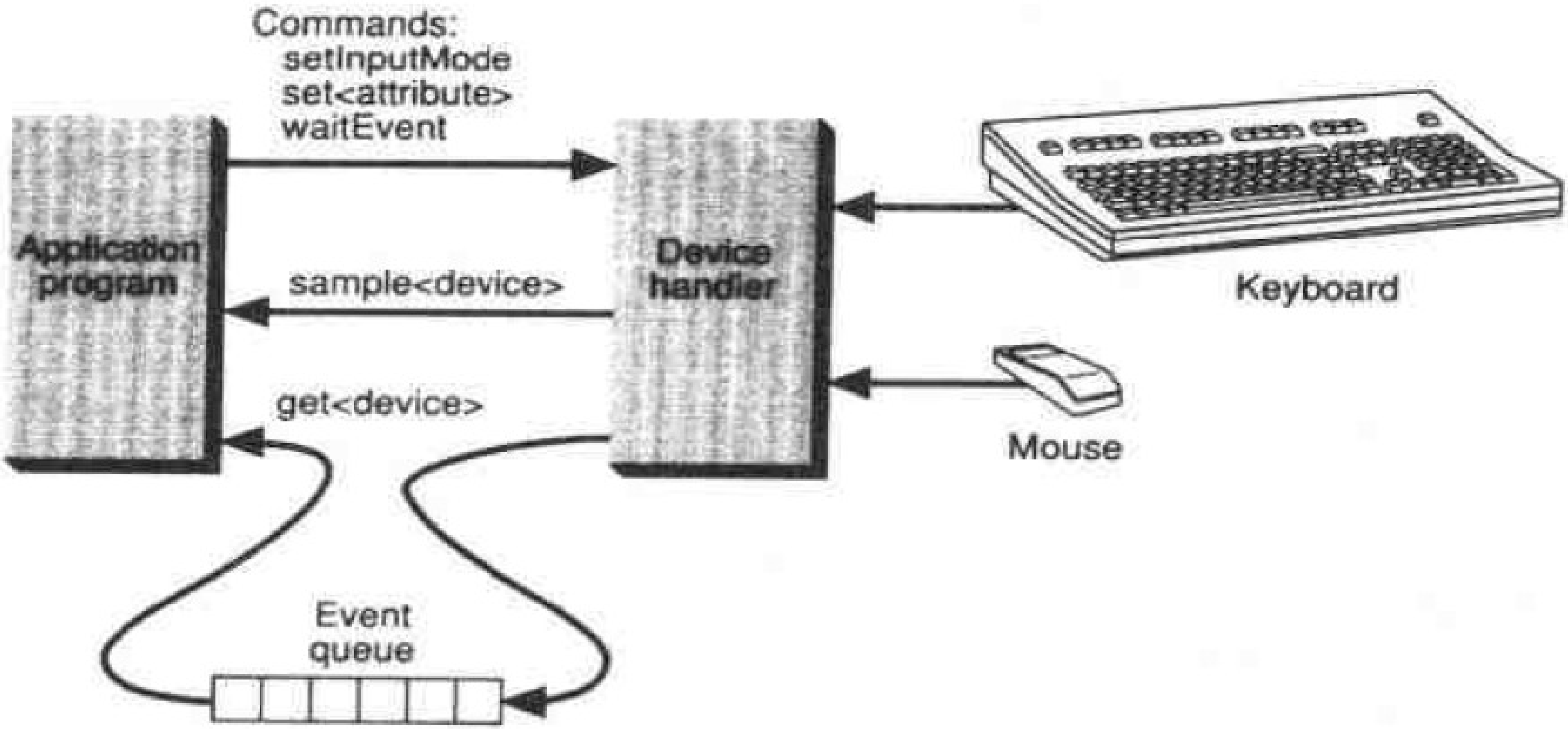


Fig. 2.16 Sampling versus event-handling using the event queue.

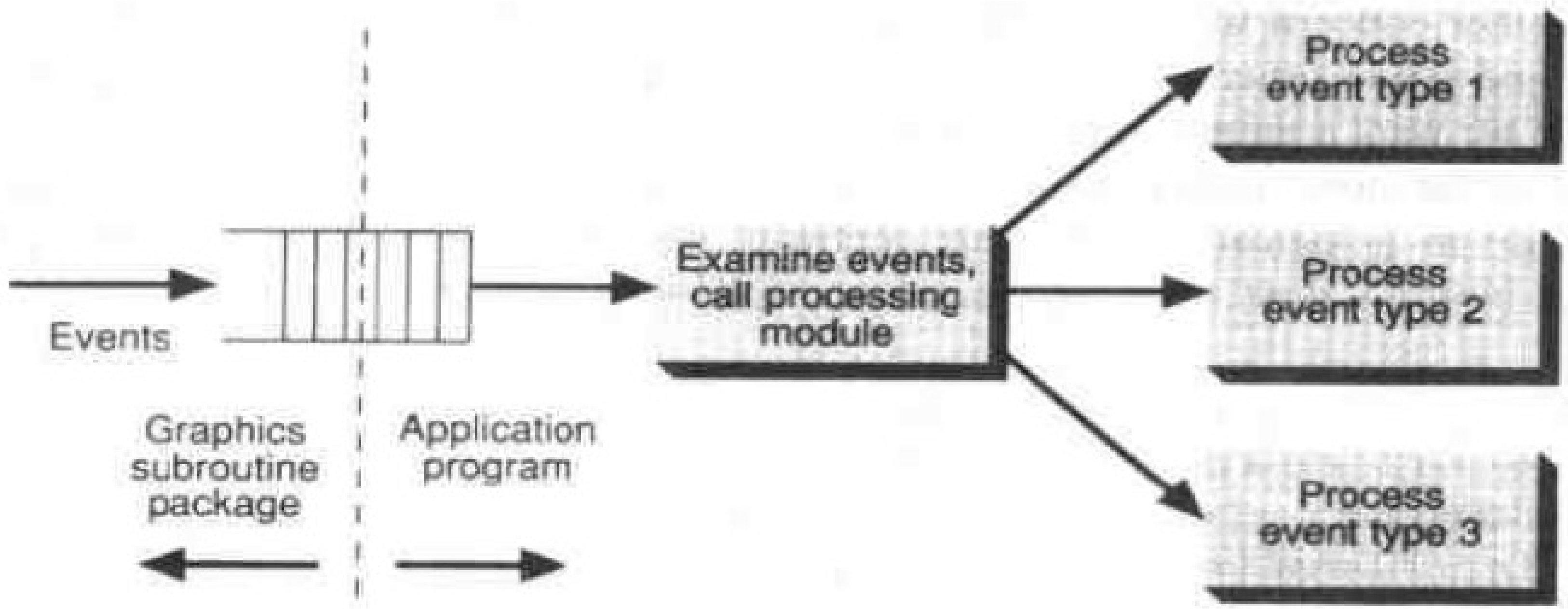


Fig. 10.2 The application program removes events from the queue and dispatches control to the appropriate procedure, which processes them.

```
initialize, including generating the initial image;
activate interactive device(s) in event mode;
while (user has not requested quit) {        /*  main event loop  */
    wait for user-triggered event on any of several devices;
    switch (device that caused event) {
        case DEVICE_1: collect DEVICE_1 event measure data, process, respond;
        case DEVICE_2: collect DEVICE_2 event measure data, process, respond;
        . . .
    }
}
```

Fig. 2.17 Event-driven interaction scheme.

Application programmer's model of graphics system

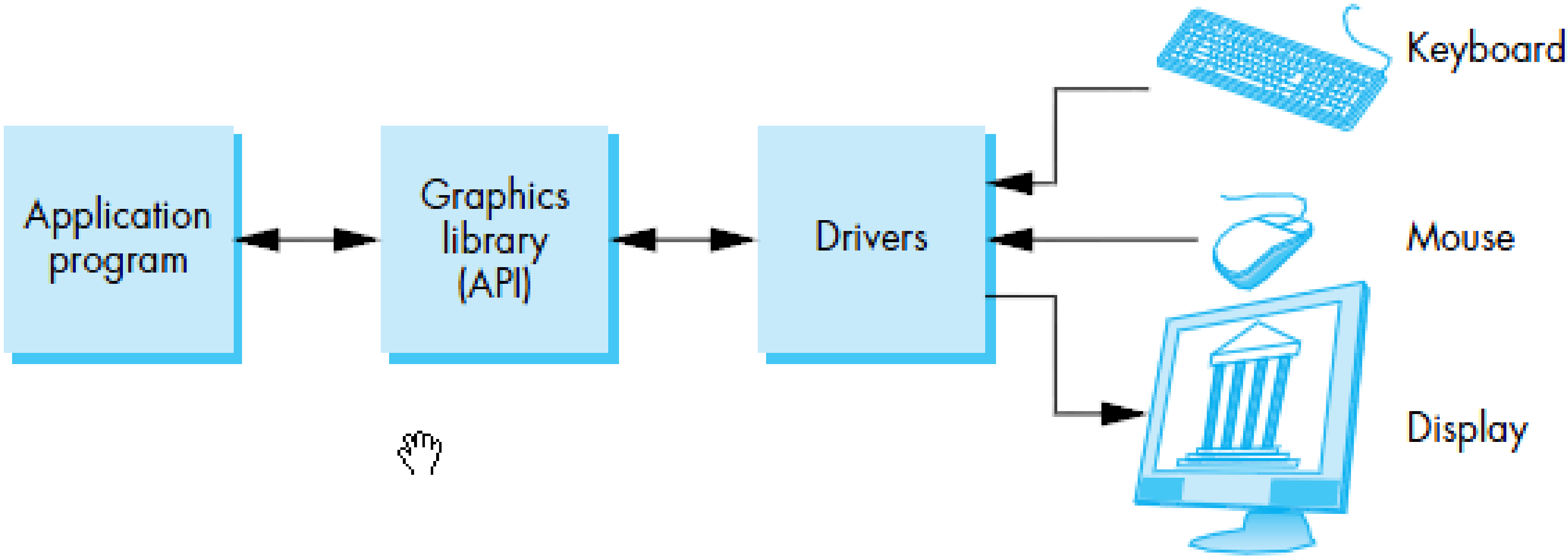
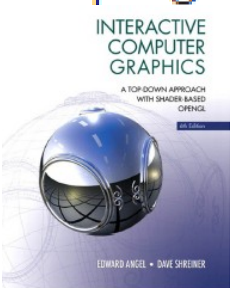
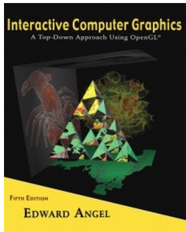


FIGURE 1.28 Application programmer's model of graphics system.



http://www.pearsonhighered.com/educator/academic/product/0,3110,0321535863,00.html



Logic of GUI v.s File system

Processes

File System Calls

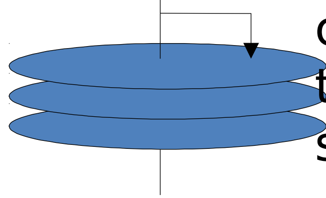
File System

map files to disk blocks …

nap disk block number
o physical
isk address
cyl#,track#,
ector#, etc)

Disk Driver

Disk Controller



Disk

cylinders, tracks, sectors

Organize GUI components – WIMP, and compute the representations with primitive figures, OpenGL, DirectX

Provide basic figures like lines, region, etc. Several standards: GKS, PHIGS, CGI

Map the figures in VC's memory as pixels/dots to display

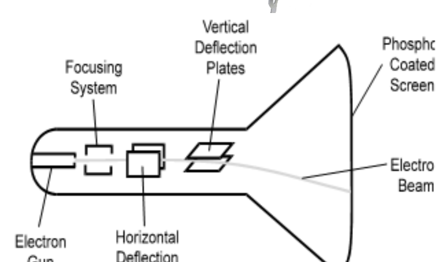
GUI applicati

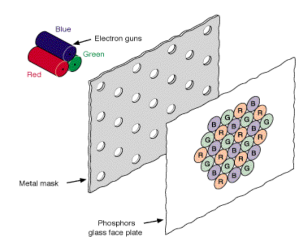
Graphic Application Software

Graphic Support Software

Video card Driver

Video card





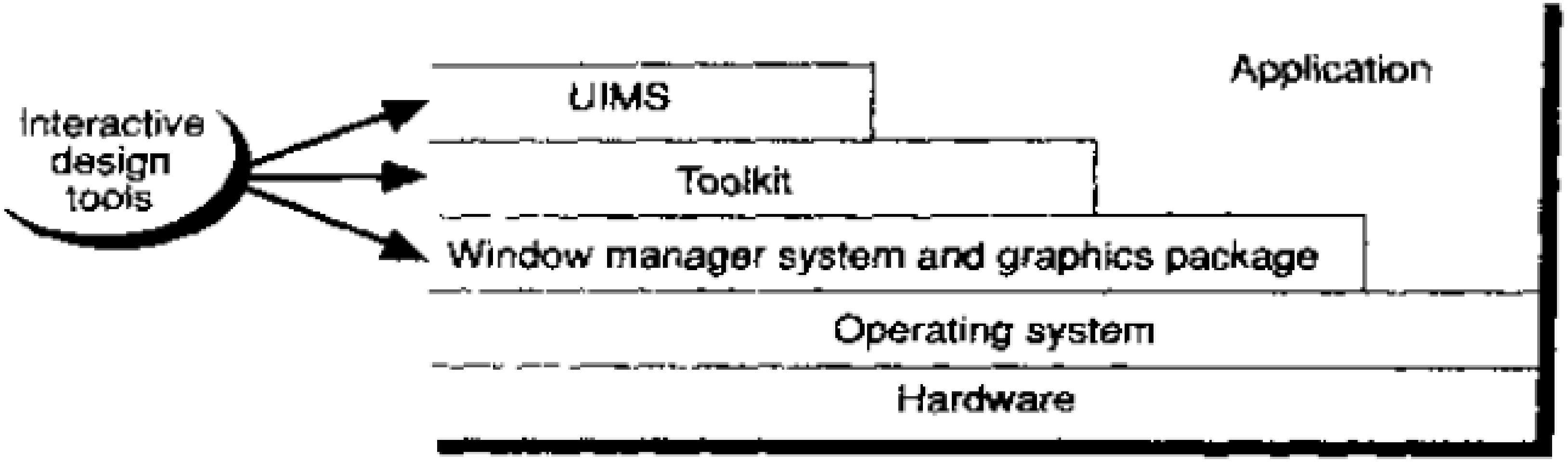


Fig. 10.1 Levels of user-interface software. The application program has access to the operating system, window-manager system and graphics package, toolkit, and user-interface management system (UIMS). The interactive design tools allow nonprogrammers to design windows, menus, dialogue boxes, and dialogue sequences.

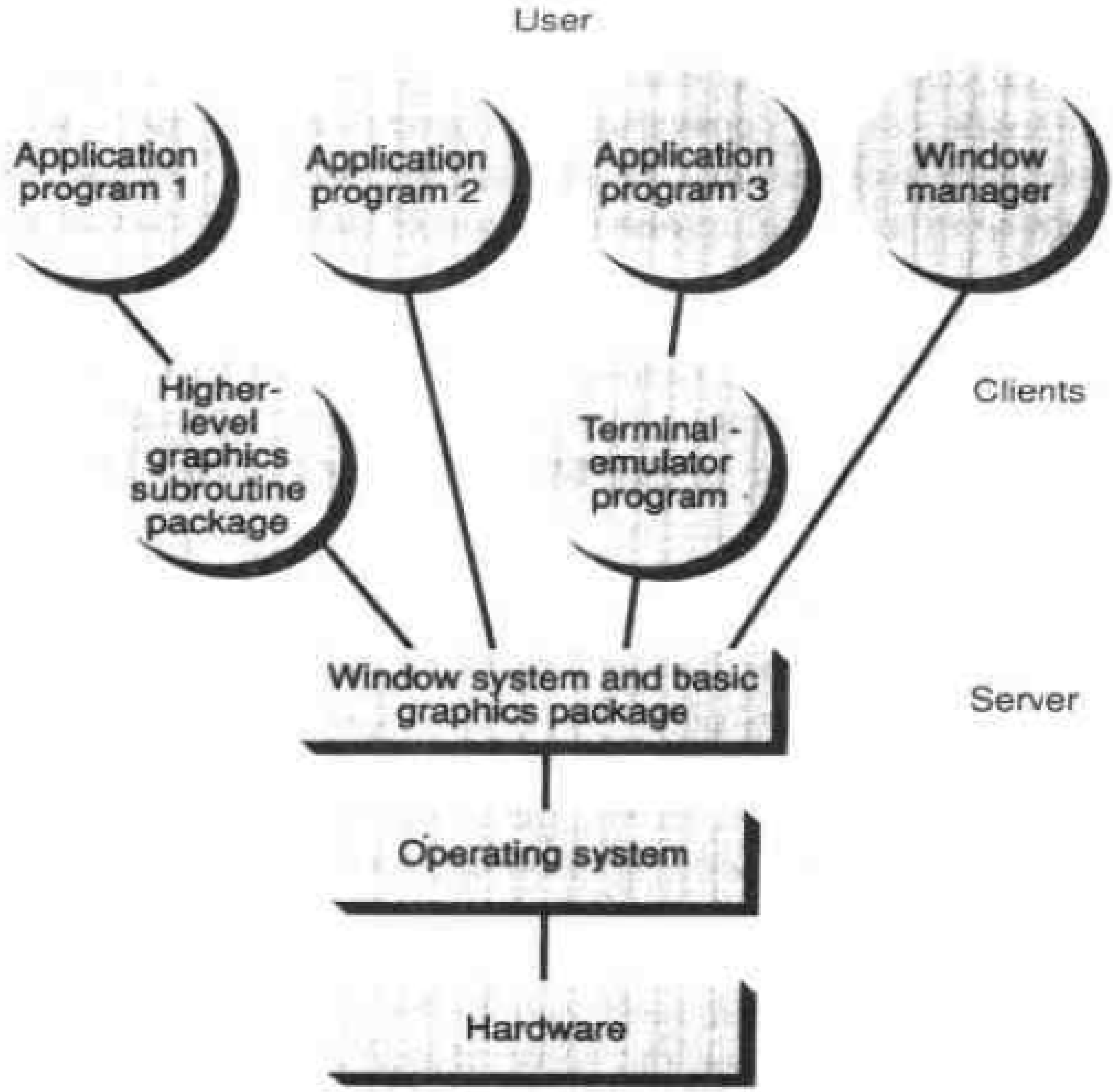
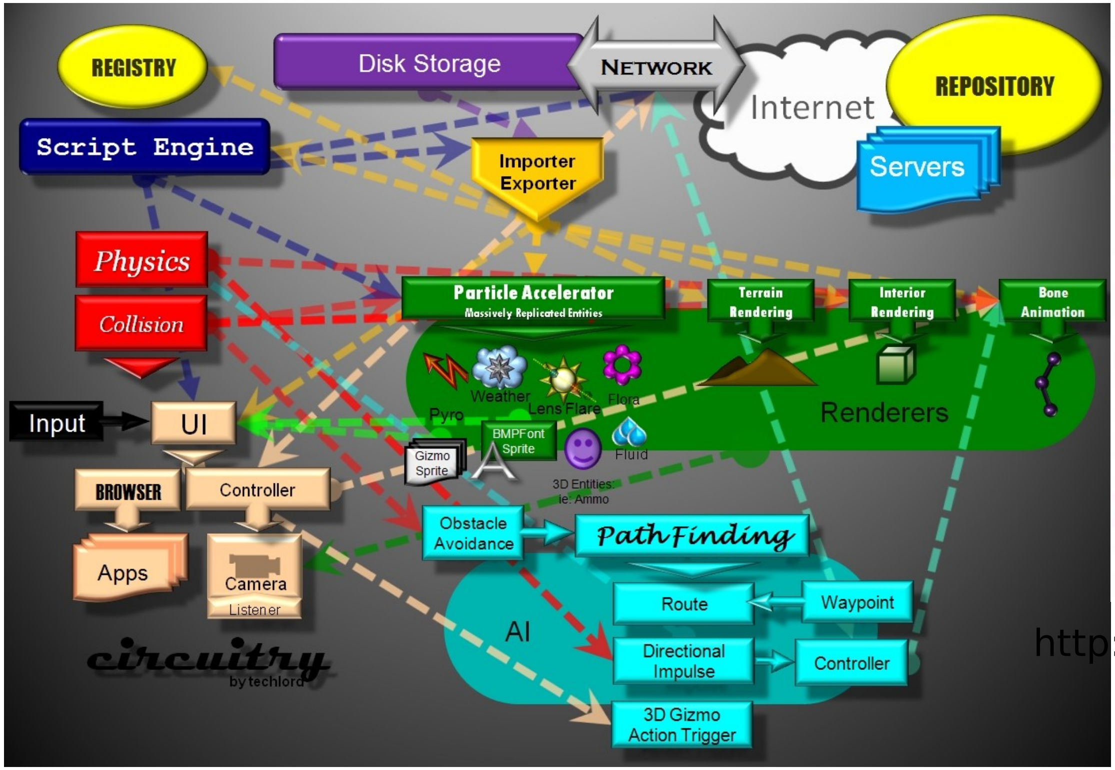


Fig. 10.4 The relationship of the window system to the operating system and application programs.

Game Engines

- There are many game engines which are proposed by game producers for special game figures and components



http://forum.thegamecreators.com/?m=forum_view&t=165850&b=19

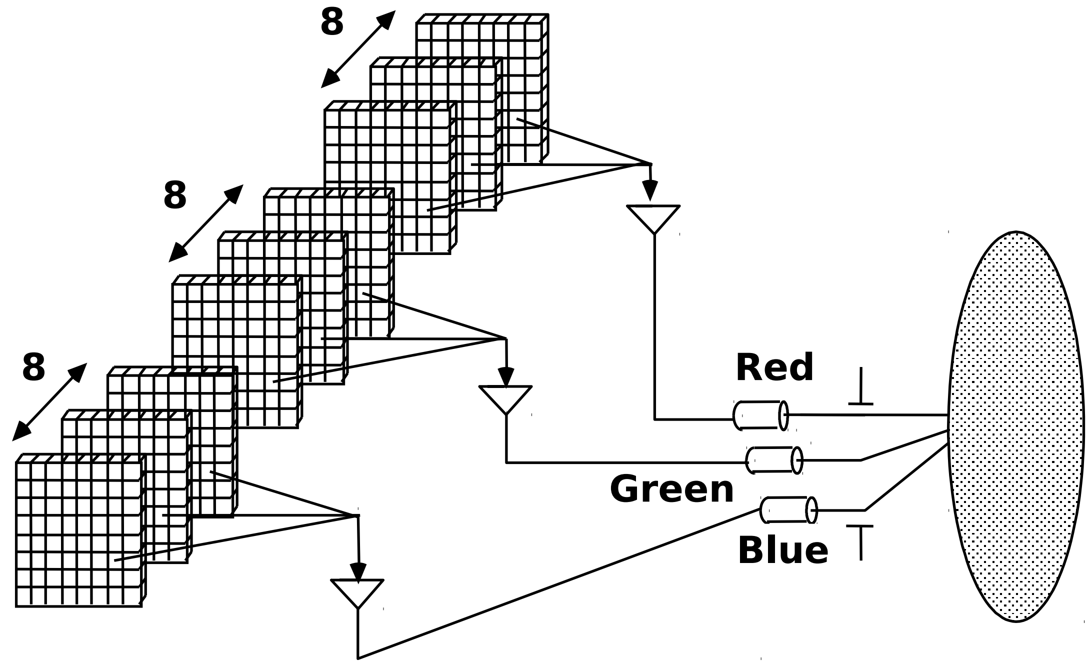
http://khmergame.com/torque_game.ht

GO
O-e
e

- GUI and its history
- Mechanism of GUI devices
- Support from OS
- Complements
  - – Colorful GUI
  - – 3D Input/Output
  - – Virtual Reality
    - Do you remember Avatar?

Specifying Color

- direct color :
  - each pixel directly specifies a color value
    - e.g., 24bit : 8bits (R) + 8bits(G) + 8 bits(B)
- palette-based color : indirect specification
  - use palette (CLUT)
    - e.g., 8 bits pixel c



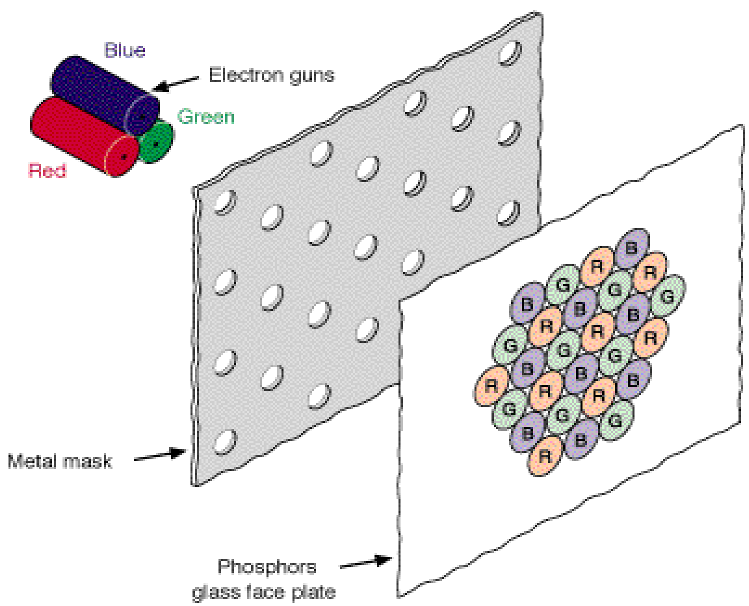
24 bits plane, 8 bits per color gun.

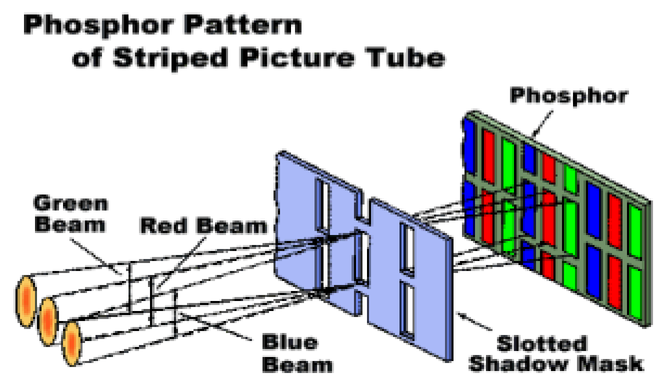
$2^{24} = 16,777,216$

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_GraphicDevices.ppt

Color CRTs

- Color CRTs have
  - Three electron guns
  - A metal *shadow mask* to differentiate the beams

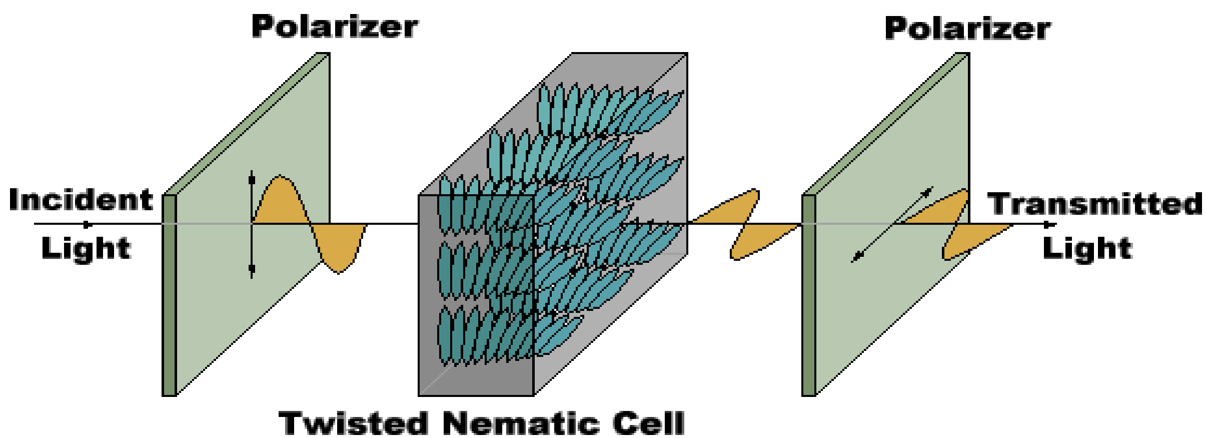




http://www.udayton.edu/~cps/cps460/notes/displays/

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

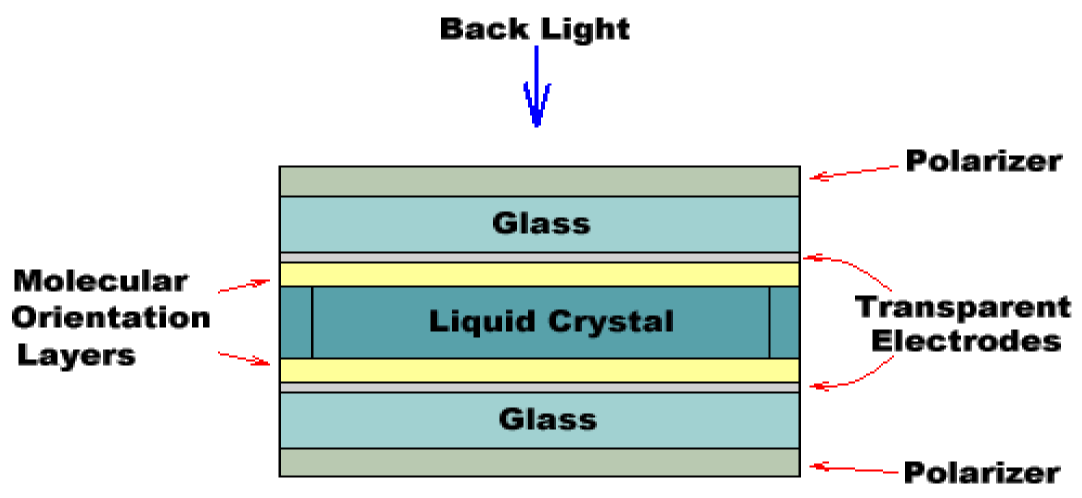
LCDs

- Liquid Crystal Displays (LCDs)
  - LCDs: organic molecules, naturally in cry stalline state, that liquefy when excited b y heat or E field
  - Crystalline state twists polarized light 90º
    - 

http://www.udayton.edu/~cps/cps460/notes/displays/

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

- Transmissive & reflective LCDs:
  - LCDs act as light valves, not light emitters, and thus rely on an external light source.
  - Laptop screen: backlit, *transmissive display*
  - Palm Pilot/Game Boy: *reflective display*



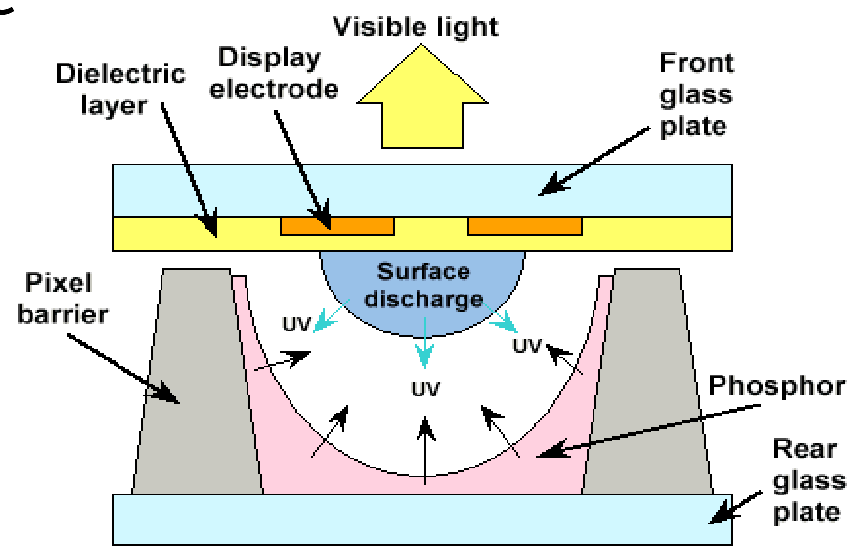
http://www.udayton.edu/~cps/cps460/notes/displays/

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

Plasma [等离子]

- Plasma display panels
  - Similar in principle to fluorescent light tubes
  - Small gas-filled capsules

    are excited by electric fie ld,
    emits UV light
  - UV excites phosphor
  - Phosphor relaxes, emits some other color



http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

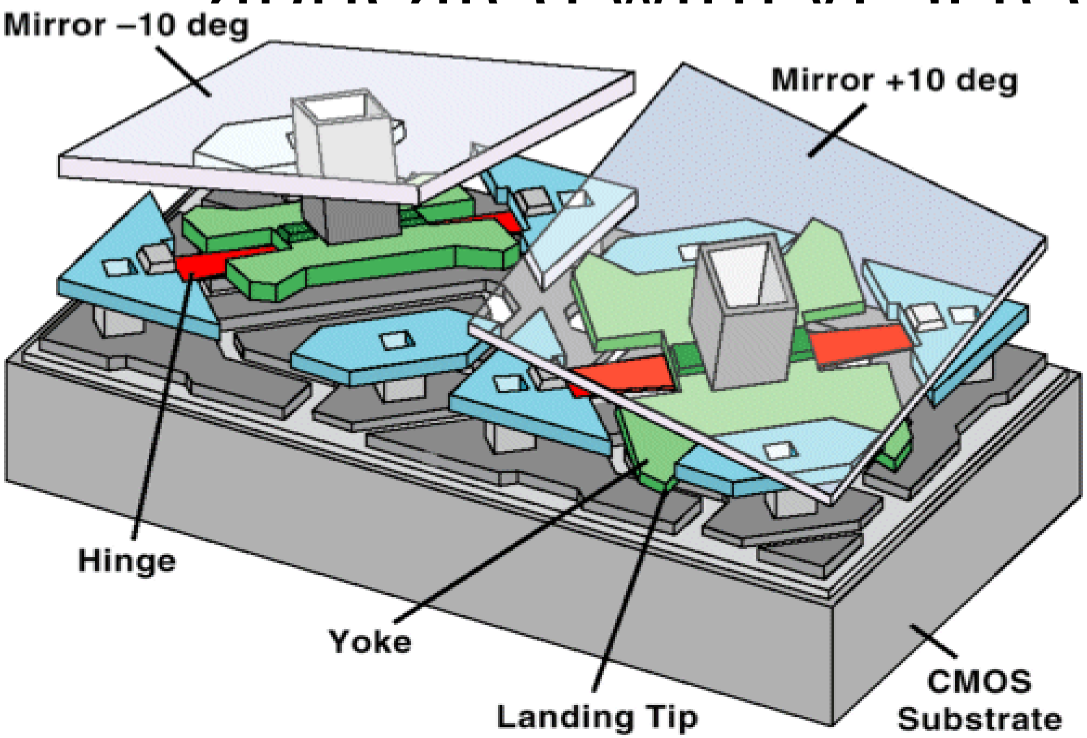
Plasma Display Panel Pros and Cons

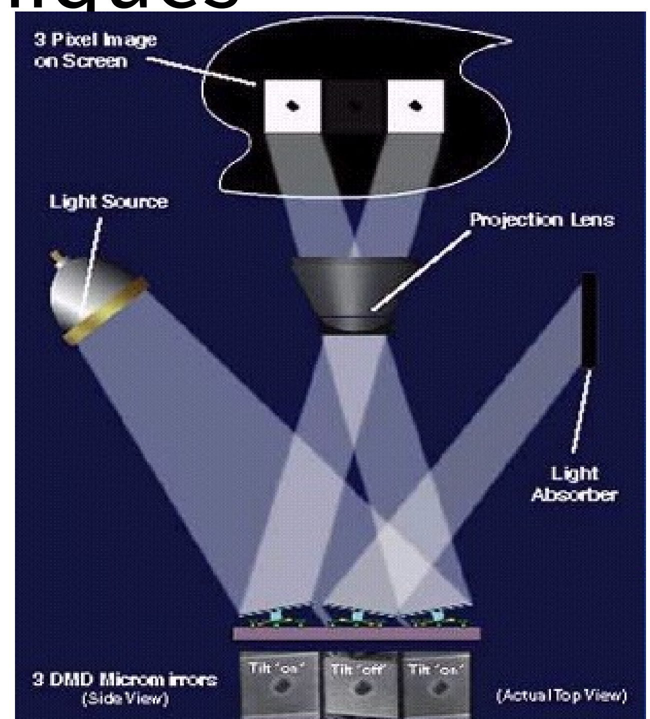
- Plasma Display Panel Pros
  - Large viewing angle
  - Good for large-format displays
  - Fairly bright
- Cons
  - Still very expensive
  - Large pixels (~1 mm versus ~0.2 mm)
  - Phosphors gradually deplete
  - Less bright than CRTs, using more power

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

DMDs [数字微镜器件]

- Digital Micromirror Devices (projector s)
  - Microelectromechanical (MEM) devices, f abricated with VLSI techniques





http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

DMDs Pros and Cons

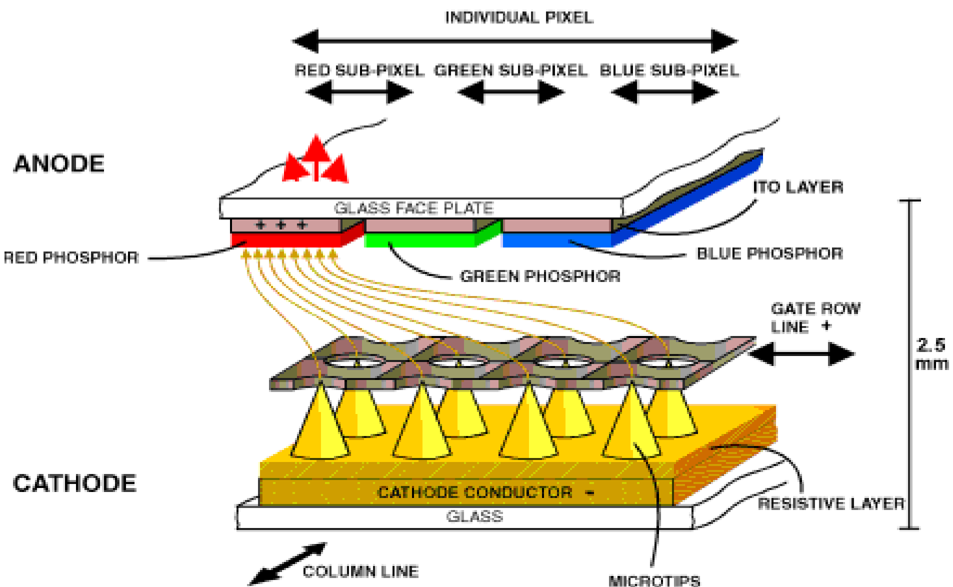
http://en.wikipedia.org/wiki/Digital_micromirror_device

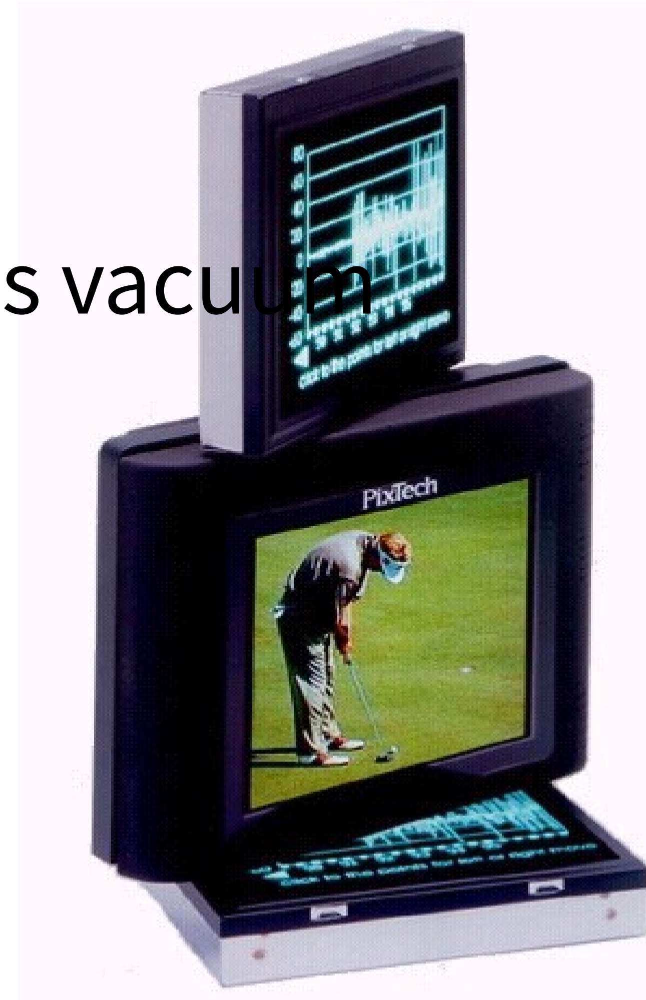
- DMDs are truly digital pixels
- Vary grey levels by modulating pulse length
- Color: multiple chips, or color-wheel
- Great resolution
- Very bright
- Flicker problems

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

FEDs [场致发射器件]

- Field Emission Devices (FEDs)
  - Like a CRT, with many small electron guns at each pixel
  - Unreliable electrodes, needs vacuum
  - Thin, but limited in size





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Organic LED [全球有机发光二极管] Arrays

- Organic Light-Emitting Diode (OLED) Arrays
  - The display of the future? Many think so.
  - OLEDs function like regular semiconductor LEDs
  - But with thin-film polymer construction:
    - Thin-film deposition or vacuum deposition process

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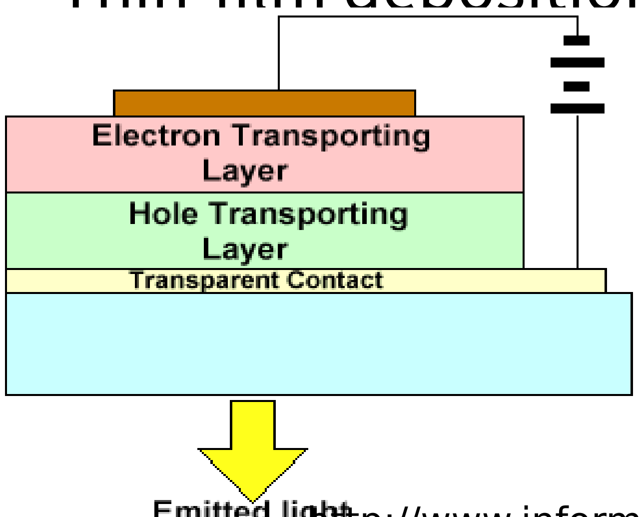
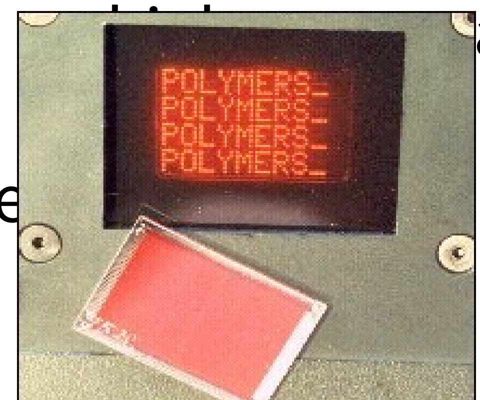
arge

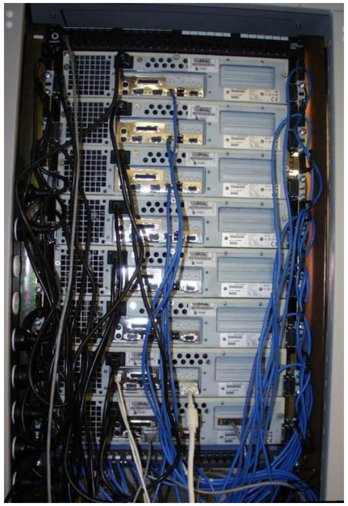




http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

Render farms

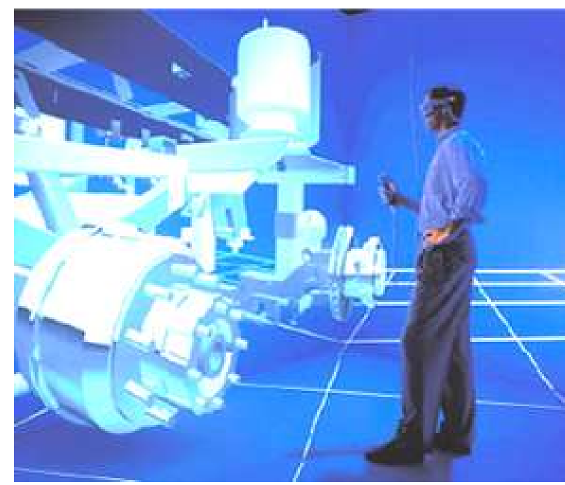
- Closely related to Beowulf c lusters
- Idea: Use many tightly-cou pled off-the-shelf machines to do rendering
- Problem: Dividing the work
- But sometimes easy, e.g. on e frame per machine
- Example: Titanic water effe cts used cluster of about 16 0 Alphas running Linux/NT.



http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

3D Input Device

- Electromagnetic trackers
  - can be attached to any head, hands, joints, objects
  - Polhemus FASTRAK™(used in Brown’s Cave)
- Acoustic-inertial trackers
  - Intersense IS-900



http://www.polhemus.com/ftrakds.htm http://www.isense.com/products/prec/is900/index.

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

3D Input Device

- Gloves
  - attach electromagnetic tracker to the hand
- Pinch gloves
  - contact between digits is a "pinch" gesture
  - in CAVE, extended Fakes ™ gloves tra contacts

http://www.fakespacelabs.com/products/pinch.htm

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

Video Output Devices

- Classification
  - Stereo
    - head-mounted displa ys
    - shutter glasses
  - Degree of immersion
    - conventional desktop screen
    - walkup VR, semi-imm ersive displays immer sive virtual reality

http://robotics.aist-nara.ac.jp/equipments/E-equips/hmd.html

http://www.virtualresearch.com/index.html

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

Video Output Devices

Example of Immersive Display

- Diffusion Tensor MRI Brain Visualization at Brown University

http://www.cs.brown.edu/research/graphics/research/sciviz/brain/brain.ht

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap

Video Output Devices

- Immersive
  - Head-mounted displays (HM
  - Stereo shutter glasses
  - Virtual Retinal Display (VRD)
  - CAVE™

http://www.evl.uic.edu/research/template_res_project.php3?indi=27

http://www.informatics.buu.ac.th/~kubola/310355/Lectures/02_Grap


WWW.IPC.ME
iPc.me
6
Subway service suspended.
Walking route
Wanna meet up today?

It’s time!


Twitter
Maps
App Store
Camera
Mail
Tuesday
9
Calendar
21:37
Tuesday, February 9

http://james-camerons-avatar.wikia.com/wiki/The_Making_of_Avatar_%28book%29

Do you remember Avatar?