

CptS 442/542 (Computer Graphics)

Unit 2: Graphics Hardware

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Dynamic Graphics Display Technology

Monitor

- LCD liquid crystal display
- PDP plasma display panel
- CRT cathode ray tube
- OLED organic light-emitting diode
- ...

Projector

- DLP™ digital light processor
- LCD liquid crystal display
- LED light-emitting diode
- CRT cathode ray tube
- ...

and then there's...

VRD virtual retinal display

Static Graphics Display Technology

2D printing:

- ▶ film
- ▶ paper
- ▶ cloth
- ▶ ...

3D printing (“fabrication”):

- ▶ metal
- ▶ clay
- ▶ resin
- ▶ wood
- ▶ ...

Each medium has its own set of rules (of thumb, often) for quality image (or whatever) production.

Graphics Input Devices

Graphics input is all about generating events for a GUI system to handle.

device	type(s) of event
keyboard	key
mouse	motion, button
pen tablet	position, button, pressure
touch screen	position, pressure

Apart from the bare minimum we need to control a graphics program, this is the last we'll say about input devices. That's what a user interface class is for!

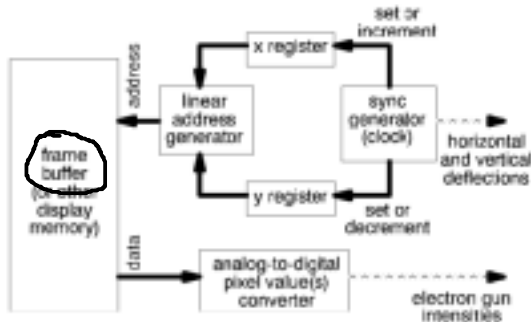
Turning Pixels into Photons

The graphics API “draws pixels” (i.e. sets bytes) in the frame buffer on the graphics card.

How do we get to see the result? ...

The Video Display Controller

Regardless of display technology, all displays need one of these in some form or another. (This one is for a CRT.)

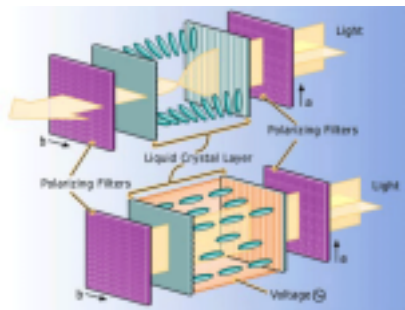


LCD Displays: One Element

RESUME

- ▶ light enters
- ▶ first polarizer does its thing
- ▶ if there's no \vec{E} field, liquid crystals "twist" polarization by 90°
- ▶ second polarizer blocks/doesn't block light

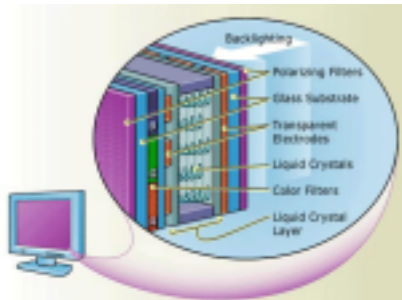
Three of these makes a pixel.



A pair of polarizing filter layers work with the liquid crystals to control emitted light. As light passes through the first filter (a), only vertically aligned light waves remain. If the liquid crystals are in their natural state, they are twisted—which causes the light wave to turn horizontally. If an electric field is applied, the liquid crystals straighten and the cell doesn't bend the light. Since the second filter (b) only lets horizontal light waves through, light that passes through the straight liquid crystals is blocked by the second filter.

Illustration by Steve McQuinn

LCD Displays: A Panel Section

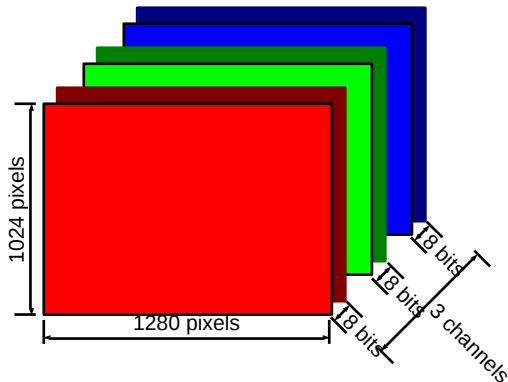


In an active-matrix color LCD, the backlight shines through a sandwich of filters, glass, and liquid crystals. First, a layer of polarizing filters align the light rays. The light then passes through cells filled with liquid crystal that, when twisted by an electrical field, bend the light. Finally, varying amounts of light drift through colored filters; these colors combine to produce the specific hue of each pixel.

Illustration by Steve Delaney

- ▶ backlight choices:
 - ▶ CCFL (cold cathode fluorescent)
 - ▶ LED (light-emitting diode)
- ▶ first polarizer
- ▶ (transparent) electrodes control \vec{E} field
- ▶ RGB filters (not needed for LED backlight)
- ▶ second polarizer

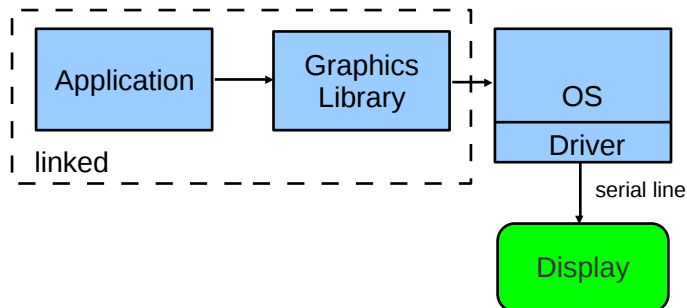
A Color Frame Buffer



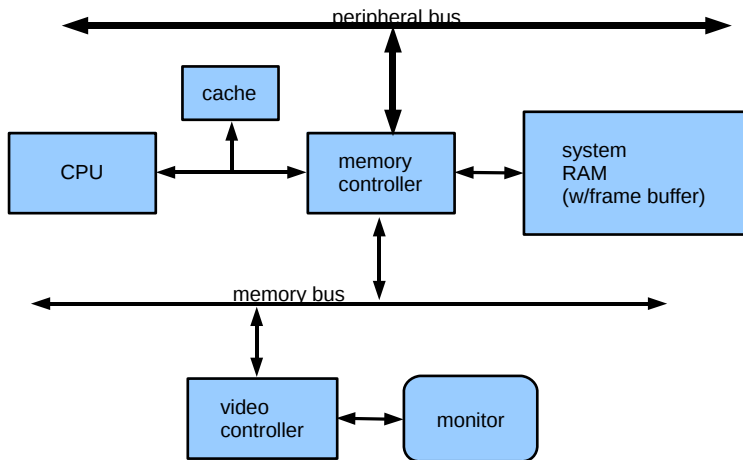
memory required:

$$1280 \times 1024 \times 3 \text{ channels} \times 1 \text{ byte/channel} \approx 4\text{MB}$$

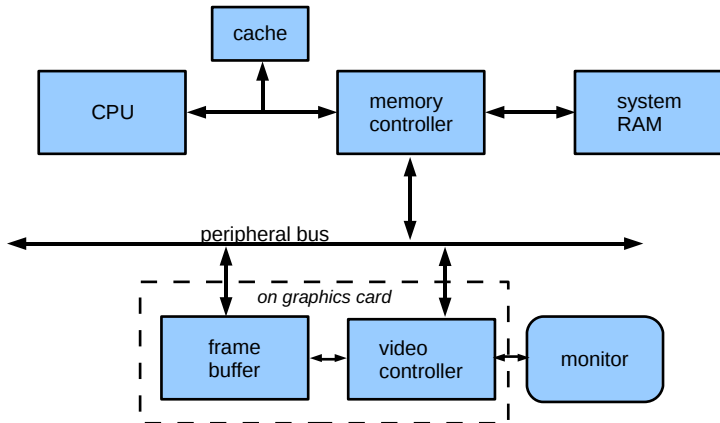
Early Graphics Architecture



Memory-Mapped Display Architecture



Separating the Frame Buffer



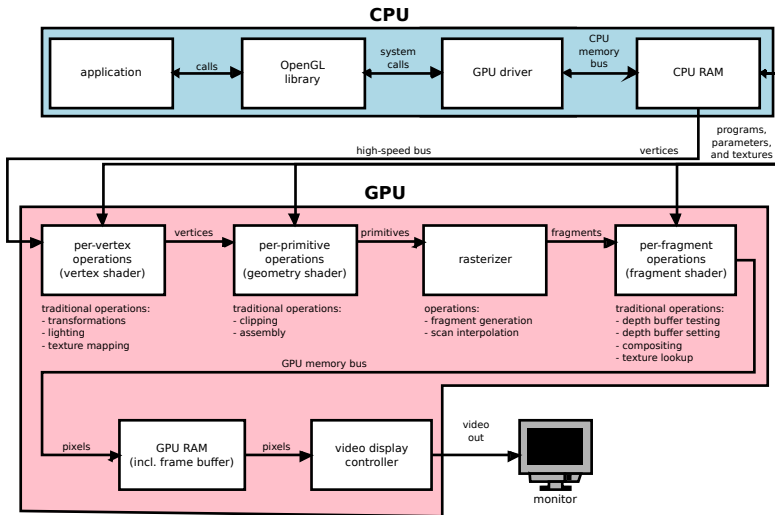
What To Do With A Graphics Accelerator?

graphics card contains:

- ▶ dedicated and programmable graphics processing unit (GPU)
- ▶ frame buffer(s)
- ▶ display memory (for textures, initially)

What software do we implement on this hardware?

The OpenGL Rendering Pipeline



OpenGL Hardware Acceleration

- ▶ perform higher-level drawing functions in hardware
- ▶ pipelining (multiple instructions in parallel)
- ▶ special purpose pixel processing
- ▶ price range:
 - ▶ \$40 PC board
 - ▶ \$50K SGI Infinite Reality Engine
- ▶ heavily driven by the game industry

GLX

- ▶ "the glue between OpenGL and X"
- ▶ encodes 3D primitives as well
- ▶ mostly window-related
- ▶ equivalent to a GLUT (later) subset, but more cumbersome
- ▶ open sourced by SGI, now part of Mesa
- ▶ see Chapter 15 of WHSL