CptS 442/542 (Computer Graphics)
Unit 2: Graphics Hardware

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Fall, 2017

Dynamic Graphics Display Technology

Monitor		Projector	
LCD	liquid crystal display	DLP™	digital light processor
PDP	plasma display panel	LCD	liquid crystal display
CRT	cathode ray tube	LED	light-emitting diode
OLED	organic 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!

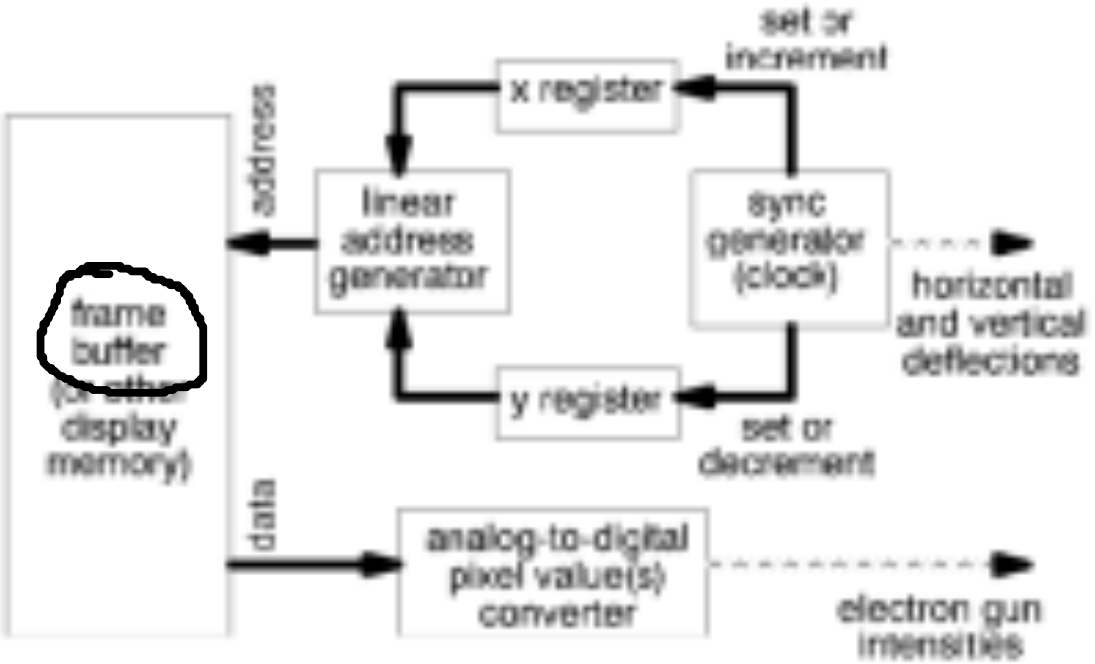
Turning Pixels into Photons

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

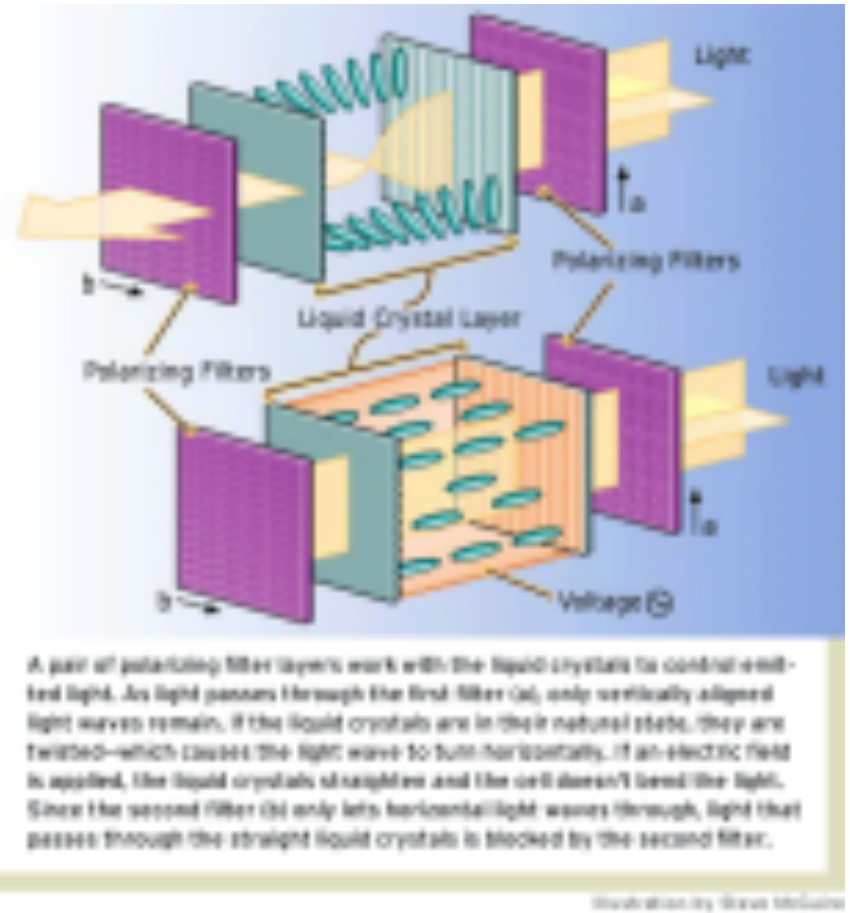
How do we get to see the result? ...

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

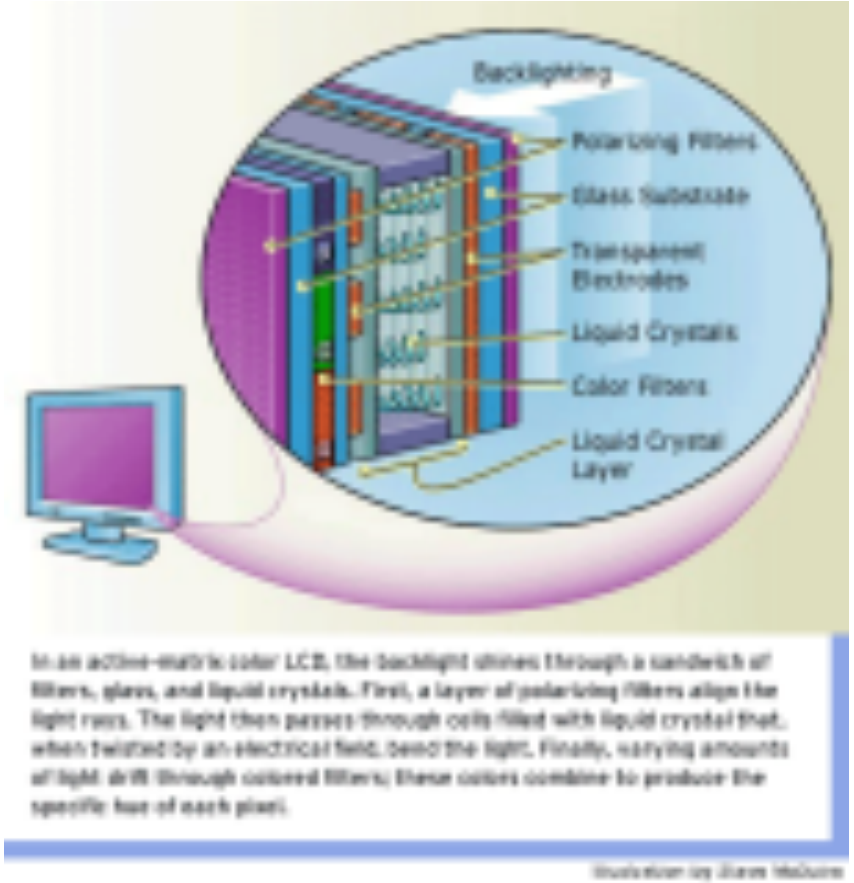


RESUME

- 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

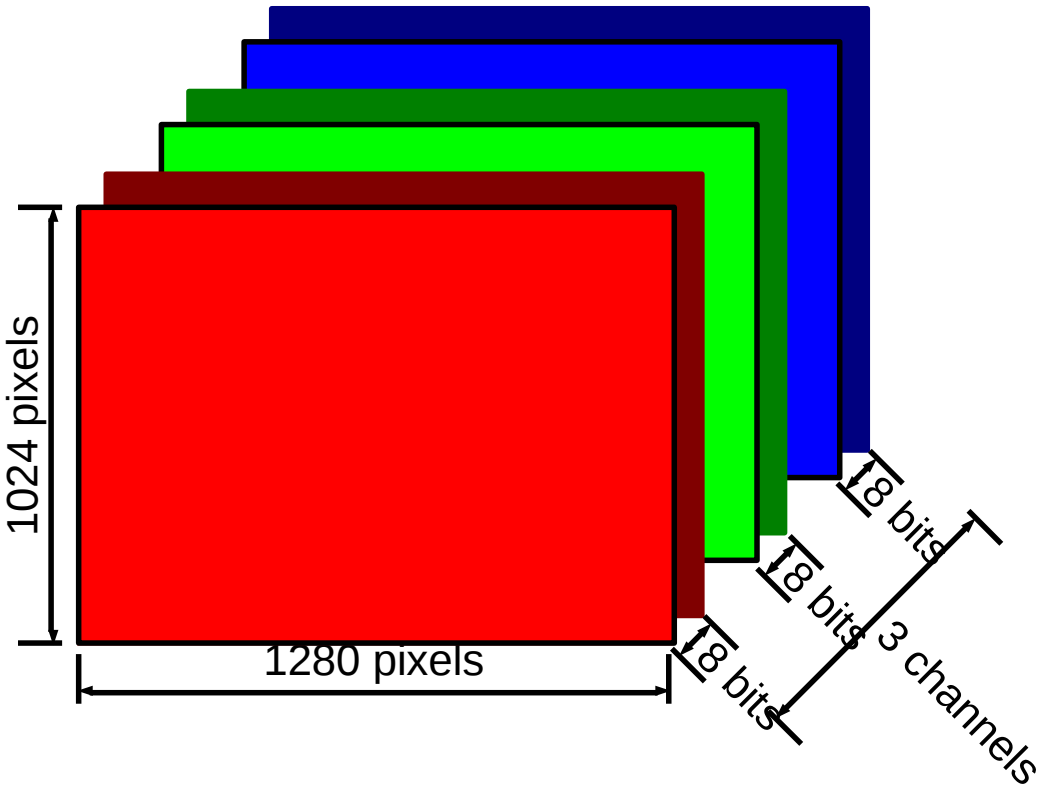
Three of these makes a pixel.

LCD Displays: A Panel Section



- 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

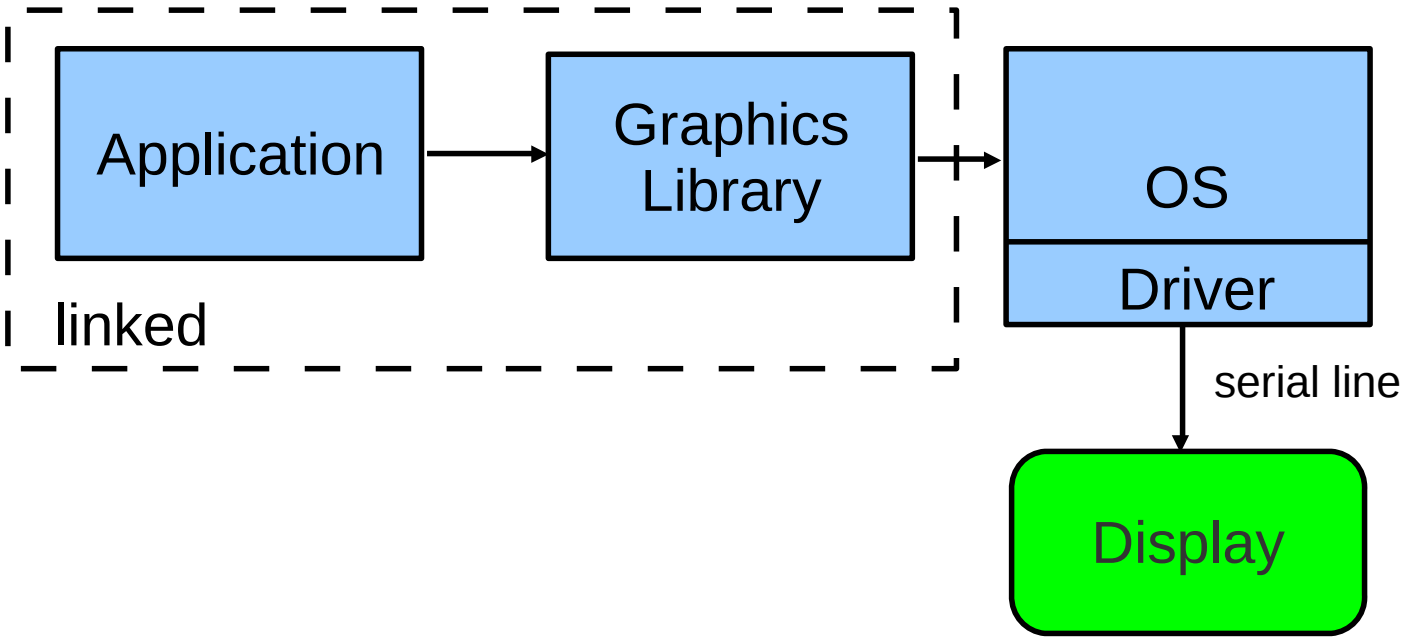
A Color Frame Buffer



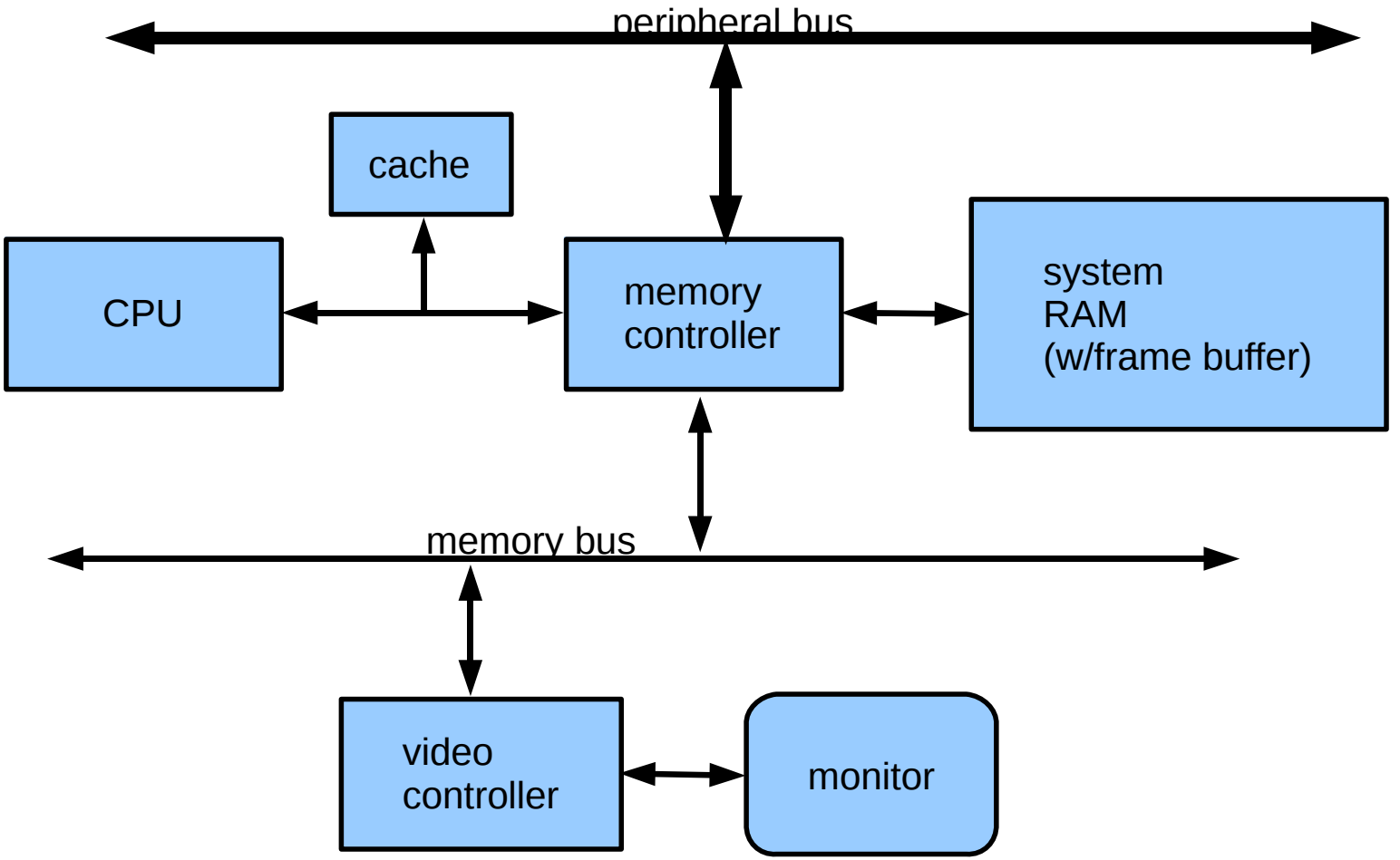
memory required:

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

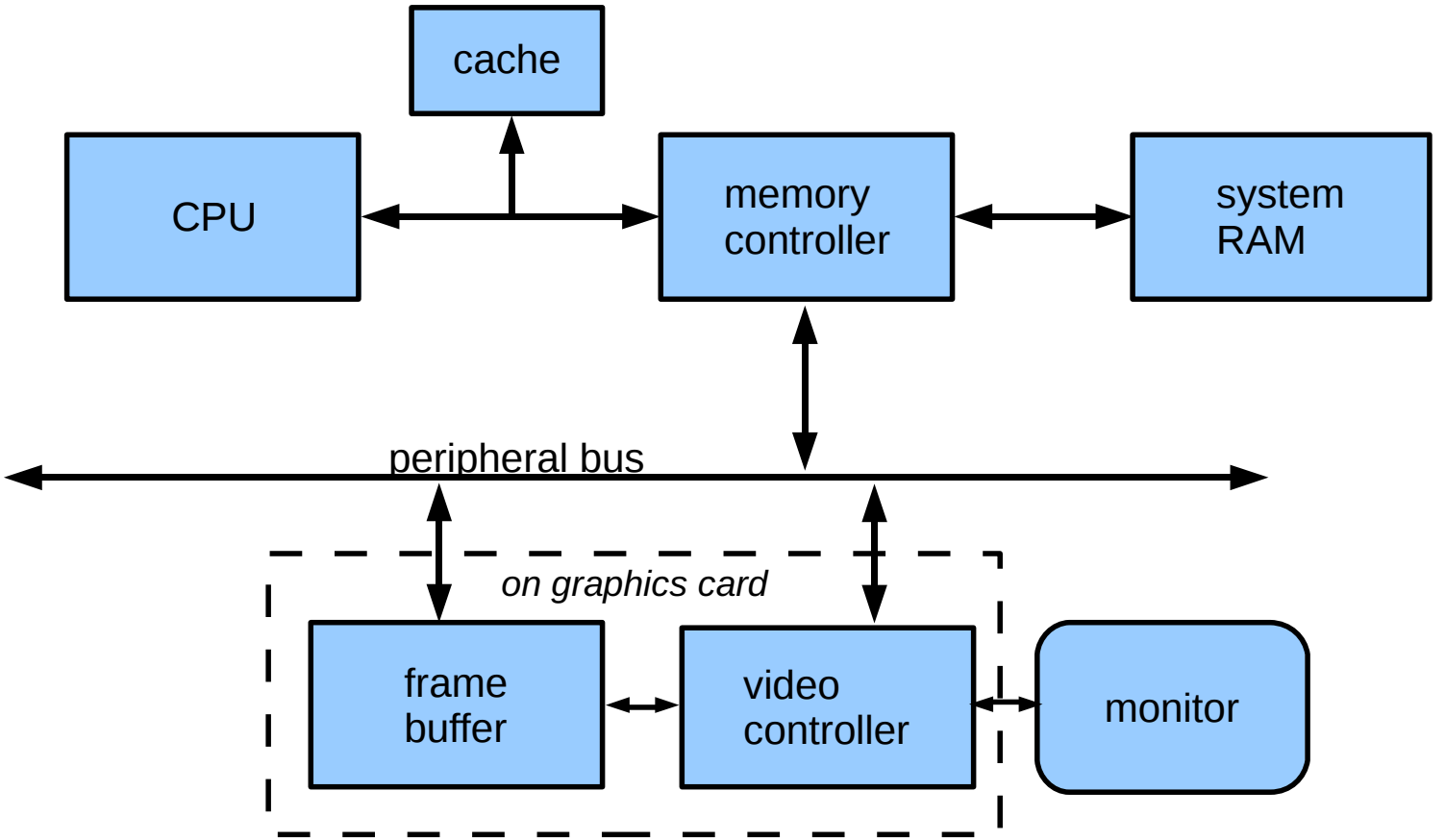
Early Graphics Architecture



Memory-Mapped Display Architecture



Separating the Frame Buffer



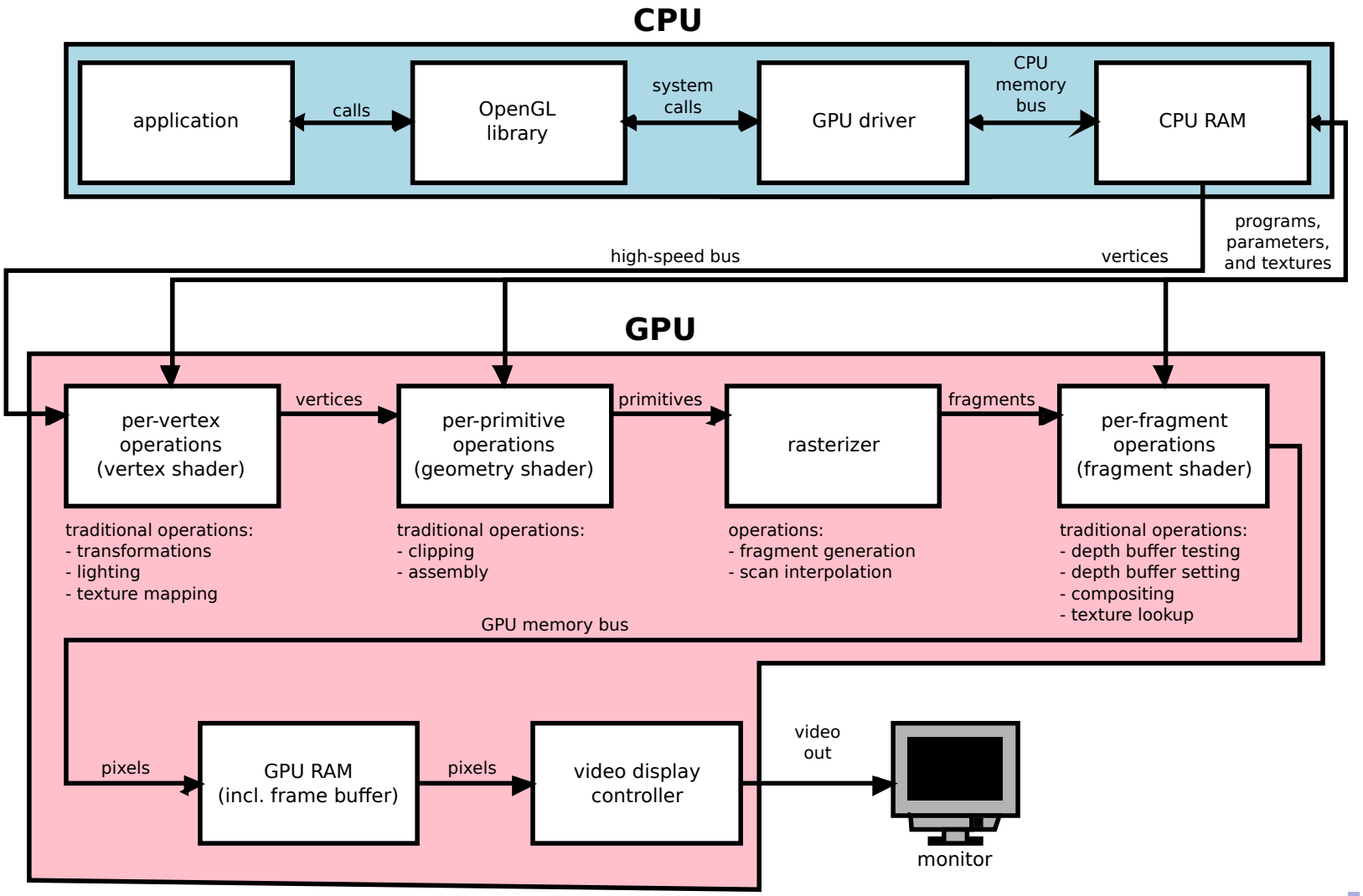
What To Do With A Graphics Accelerator?

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