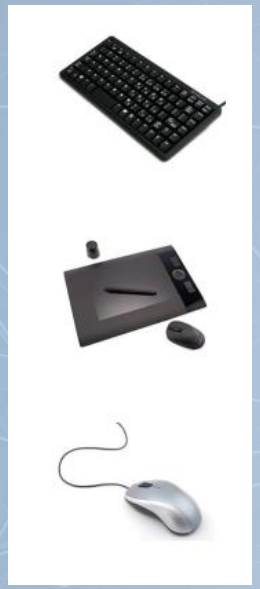
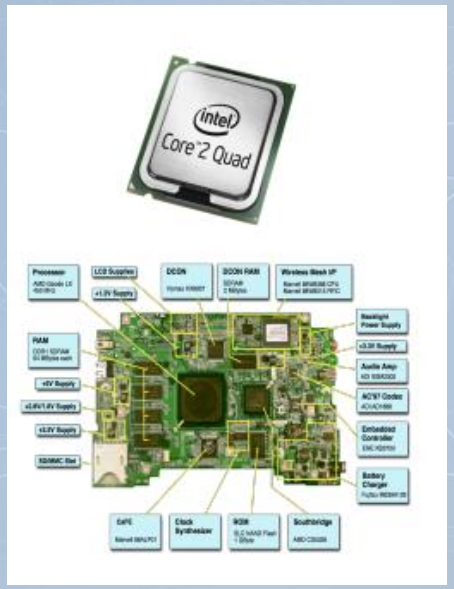
Computer Graphics Hardware

CSU0021: Computer Graphics

Graphics System



Input device



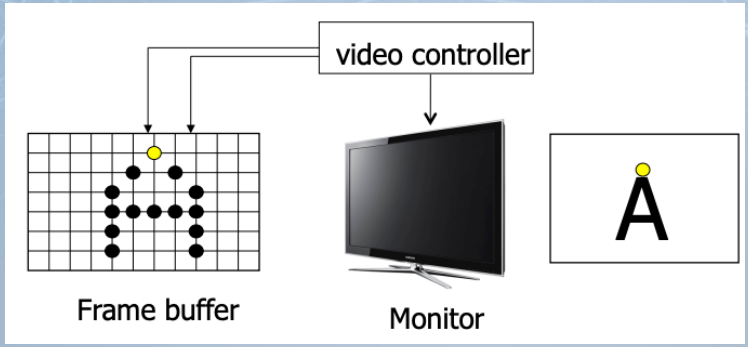
CPU/Memory

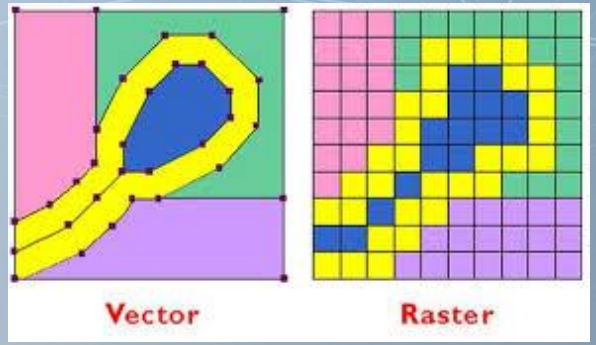
GPU/Memory

Monitor

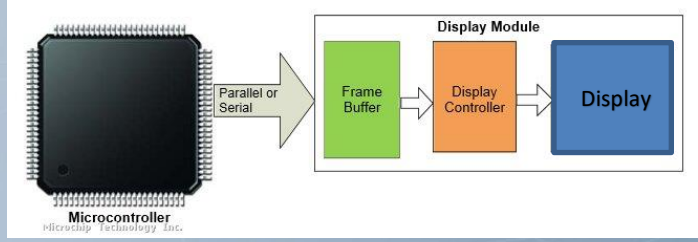
Raster Graphics System

- Raster: An array of picture elements
- Based on raster-scan TV technology
- The screen or a picture consists of discrete pixels, and each pixel has a small display area.





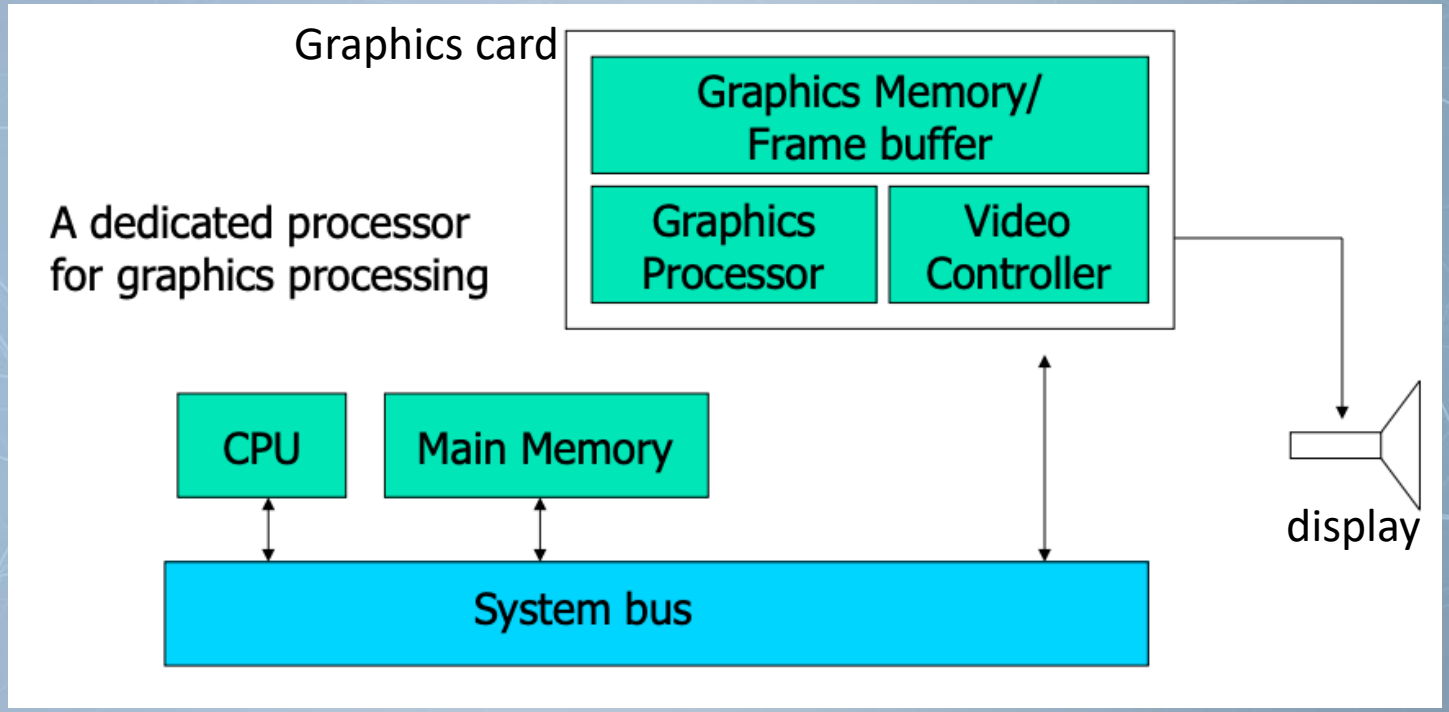
Frame Buffer



- Frame buffer: the memory to hold the pixel properties (color, alpha, depth, stencil mask, etc)

- Properties of a frame buffer that affect the graphics performance
  - Size: screen resolution
  - Depth: color level
    - 1 bit/pixel: black and white
    - 8bits/pixel: 256 levels gray or color pallet index
    - 24bits/pixel: 16 million colors
  - Speed: refresh rate

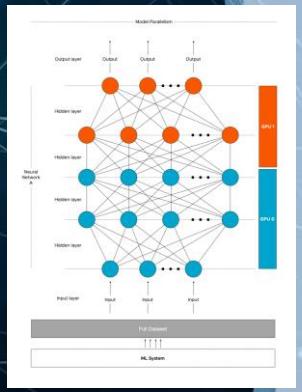
Graphics Acceleration (card)



Graphics Accelerator (card)

ATI TECHNOLOGIES INC.

What do GPUs (graphics card) do?

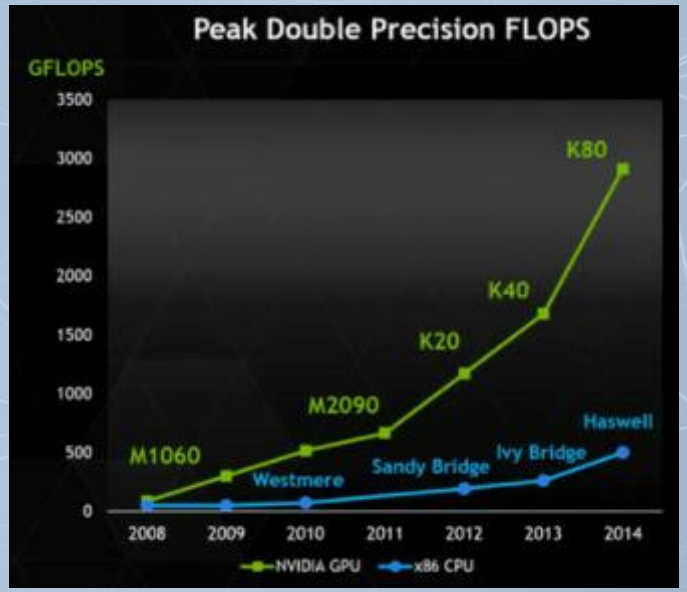


- GPUs are massively parallel processors
  - Process geometry/pixels and produce images to be displayed on the screen
  - Can also be used to perform general purpose computation (via CUDA/ OpenGL)

- Evolved from simple video scan controllers, to special purpose processors that implement a simple pipeline with fixed graphics functionality, to complex many-core architectures that contain several deep parallel pipelines
  - Example: Nvidia Tesla V100 has 5120 cores and 21.1 billions transistors
  - Nowadays, a graphics card can easily have more than 4 GB of video memory

Nvidia V100 Architecture

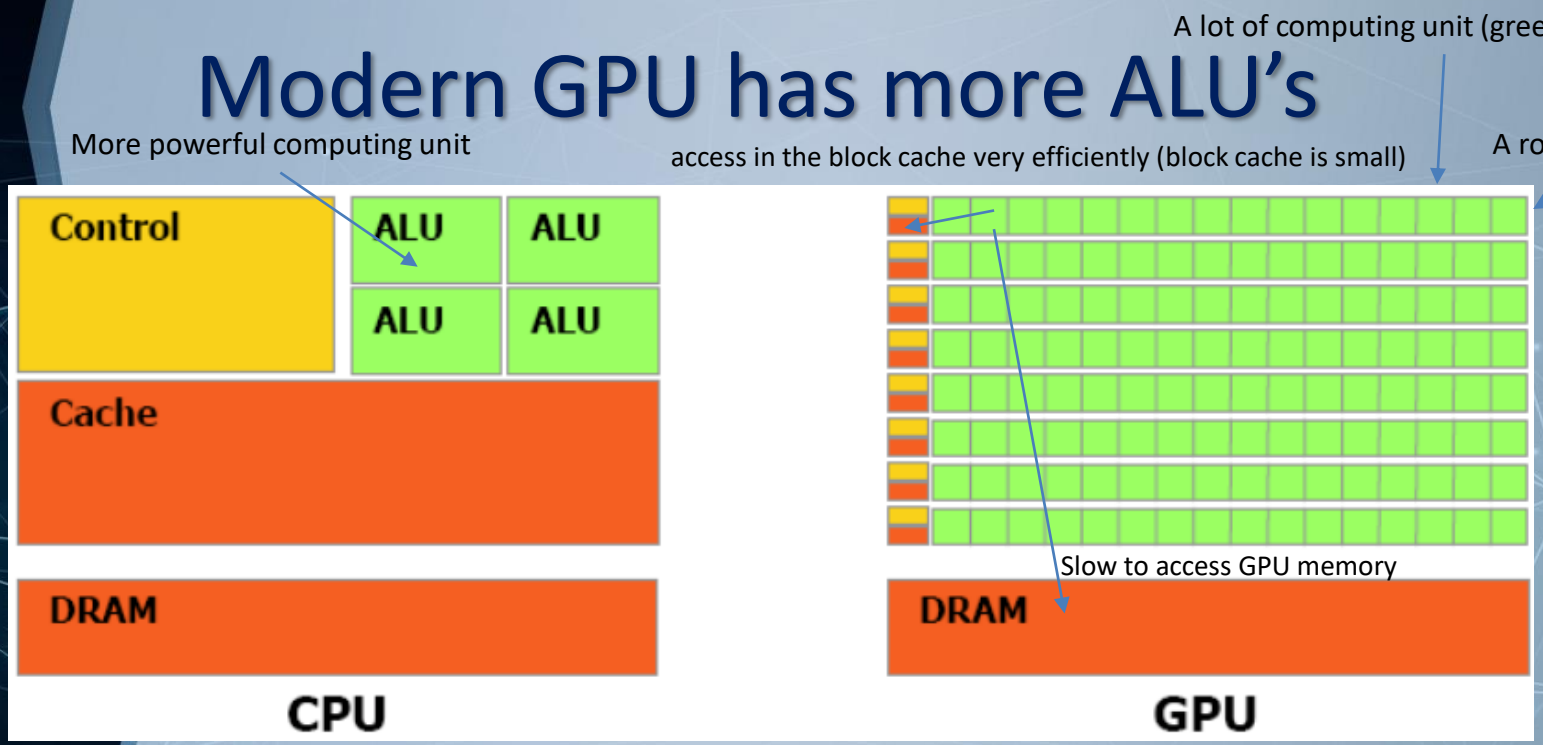
CPU/GPU Performance Gap



Why are GPU's so fast?

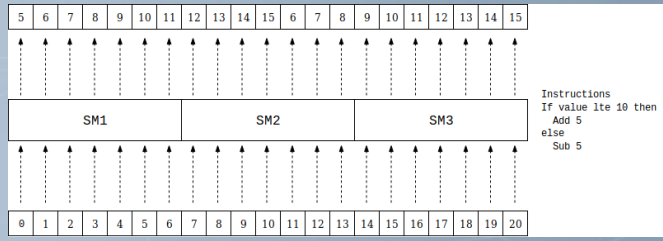
- Entertainment industry has driven the economy of these chips
  - Recently, deep learning has driven these economy, too
- Moore's Law
- Simplified design (stream processing)
- Single-chip designs

Modern GPU has more ALU's



The GPU devotes more transistors to data processing

A Specialize Processor

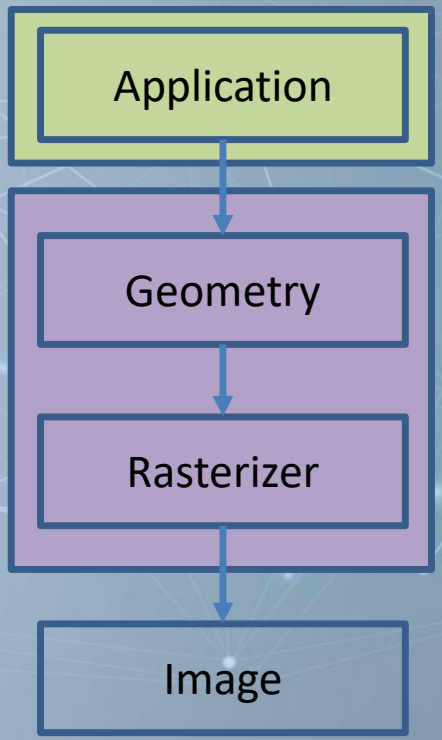


- Very efficient for
  - Fast parallel floating-point processing
  - Single instruction multiple data operations
  - High computation per memory access

- Not as efficient for
  - Double precision
  - Branching-intensive operations
  - Random access, memory-intensive operations

The Rendering Pipeline

- The basic construction – three conceptual stage
- Each stage is a pipeline and runs in parallel
- Graphics performance is determined by the slowest stage
- Modern graphics system:
  - Software:
  - Hardware:



The Rendering Pipeline

- The process to generate two-dimensional images from given virtual cameras and 3D objects
- The pipeline stages implement various core graphics rendering algorithms
- Why should you know the pipeline?
  - Necessary for programming GPUs
  - Understand various graphics algorithms
  - Analyze performance bottleneck

Rendering Pipeline

- Host interface: move data from CPU to GPU
- Vertex processing: transform vertex from object to screen space
- Triangle setup: rasterization
- Pixel processing: color pixels
- Memory interface: produce final image

The Quest for Realism