CMSC 635

Graphics Hardware
A Graphics Pipeline

- Vertex
- Triangle
- Fragment
Fragment vs. Pixel

- OpenGL terminology
- Pixel = on-screen RGBA+Z
- Fragment = proto-pixel
  - RGBA + Z + Texture Coordinates + …
  - Multiple Fragments per Pixel
    - Depth Complexity
    - Supersamples
Computation & Bandwidth

Bandwidth

- data vertex second
- interpolated triangle second
- texels fragment second
- output fragment second

Computation

- operations vertex second
- operations fragment second

Vertex

Triangle

Fragment

\[
\frac{\text{fragment}}{\text{second}} = \frac{\text{fragment}}{\text{triangle}} \cdot \frac{\text{triangle}}{\text{second}} = \text{pixels} \cdot \text{supersamples} \cdot \text{depth complexity}
\]
Pipeline

Transform
Shade
Clip
Project
Rasterize
Interpolate
Texture
Z-buffer

Vertex
Triangle
Fragment
Pipeline: Geometry Engine

Matrix Engines

Scaler Engines

Clipper Engines
Data Parallel
Graphics Data Organization

Object Order

- Vertex
- Triangle
- Fragment

Screen Order
Sort Middle

Distribute objects or vertices

- Vertex
- Vertex
- Vertex

Merge & Redistribute by screen location

- Triangle
- Triangle
- Triangle
- Triangle

- Fragment
- Fragment
- Fragment
- Fragment

Some objects

Some pixels

Screen
Screen Subdivision

- Tiled Interleaved
- Scan-Line Interleaved
- Column Interleaved

Footprint
Sort First

Distribute objects *by screen tile*

- Vertex
- Triangle
- Fragment

- Vertex
- Triangle
- Fragment

- Vertex
- Triangle
- Fragment

Some pixels
Some objects