Johns Hopkins
Engineering for Professionals

605.767 Applied Computer Graphics

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JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

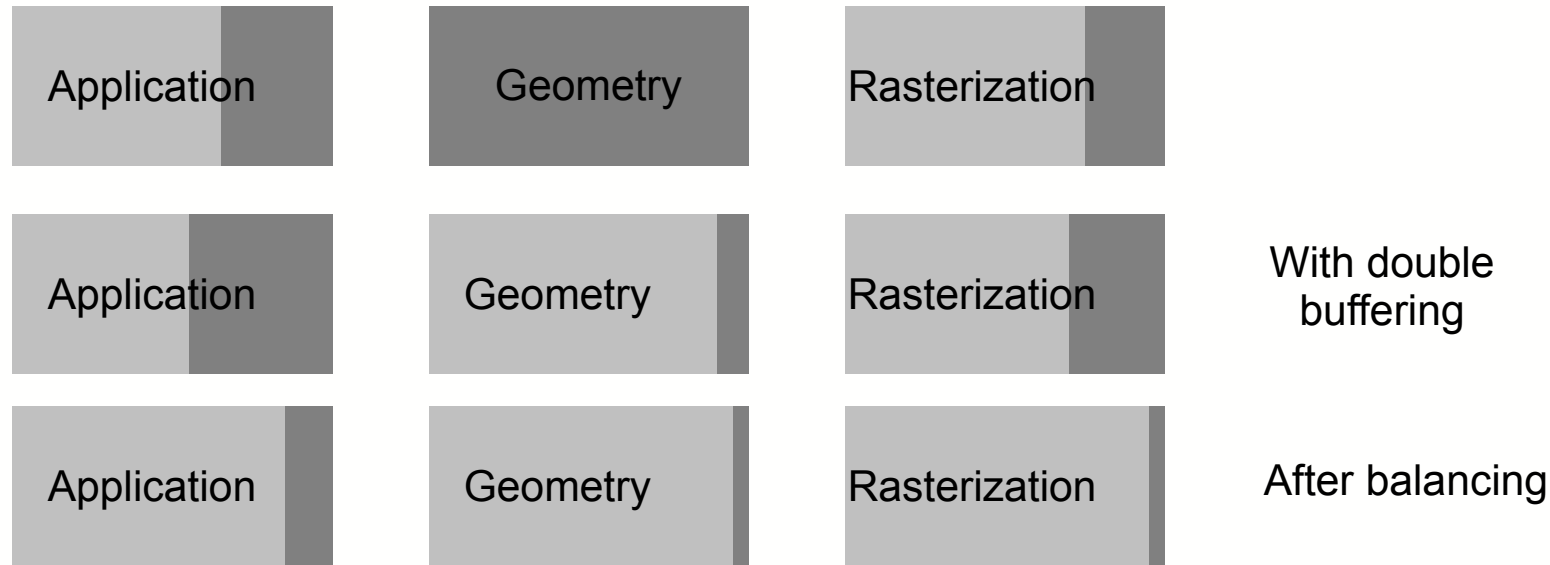# Module 11D
Balancing the Stages

Starving and Blocking

- Most pipelines have first in first out (FIFO) queues
  - One stage can continue to do work even if next stage is not ready
  - Helps balance the pipeline
- Stages can be starved
  - Example: application stage performing computations while geometry and rasterization FIFOs are empty
- Stages can be blocked
  - Example: rasterization stage is filling a large polygon and the geometry stage has filled the FIFO to the rasterizer with tasks
    - Geometry stage is blocked
- Locations of bottlenecks can vary over time within a single frame

Balancing the Graphics Pipeline

Application	Geometry	Rasterization	
Application	Geometry	Rasterization	With double buffering
Application	Geometry	Rasterization	After balancing

- In the example above the geometry stage is the bottleneck
  - % usage illustrated by dark gray
  - Double buffering causes further idle time in all stages
    - Can perform additional work as long as bottleneck stage doesn't cross into next multiple of the monitor update time
- Balancing uses the idle time in each stage to perform additional work

Uses for Idle Time

- Increase the number of triangles (affects all stages)
- Application stage
  - Compute more realistic animations, implement more accurate collision detection
- Geometry stage
  - Use more lights and more expensive light sources and options
  - Vertex shaders
- Rasterizer stage
  - More expensive texture filtering
  - Fog
  - Pixel blending
  - Pixel shaders

Balancing Tips

- Immediately after a screen clear do not fill the graphics pipeline with primitives
  - Perform application related work since graphics hardware is busy
  - Note: if all pixels are drawn at least once can avoid the screen clear
- In a fill limited application: if number of pixels filled does not change can increase the number of polygons without affecting performance of rasterization stage
  - Same object can be represented with more triangles
  - Conversely in a transform limited application the number of triangles can be decreased without impacting the number of pixels to be filled
- If the application is not fill limited the window can be enlarged