GPU-Based Volume Rendering of Unstructured Grids

João L. D. Comba — UFRGS
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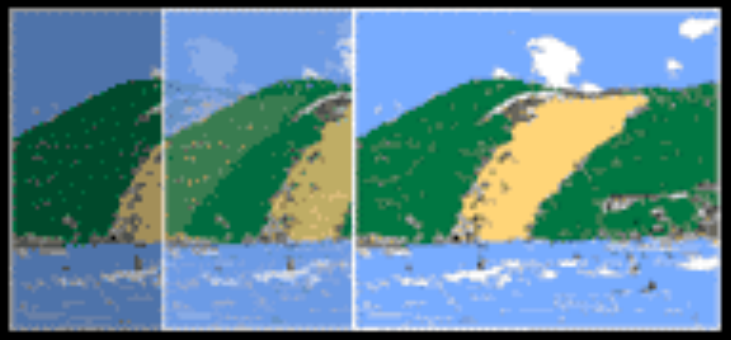

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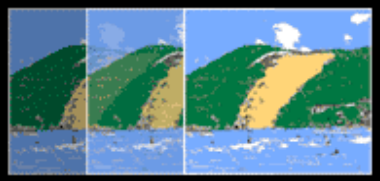

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GPU-Based Volume Rendering of Unstructured Grids

Module 1: Graphics Hardware (GPUs)

Module 2: Projected Tetrahedra Techniques

Module 3: Isosurface Techniques

break

Module 4: Hw Assisted Visibility Sorting (HAVS)

Module 5: HW Ray-Casting

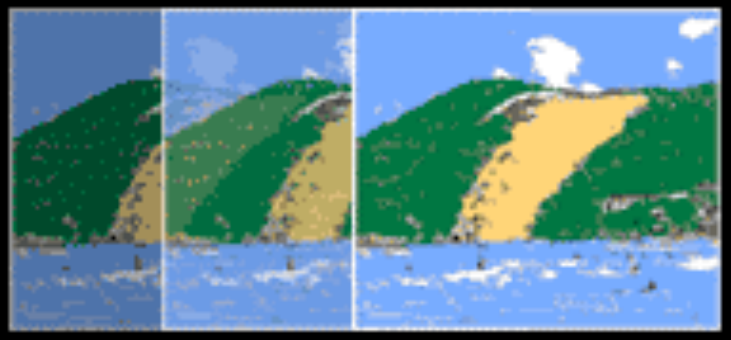
Module 6: Conclusion

GPU-Based Volume Rendering of Unstructured Grids

Module 1:
Graphics Hardware

João L. D. Comba

UFRGS



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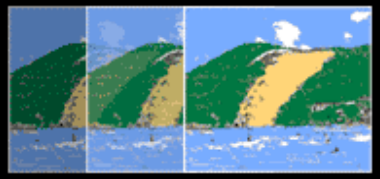

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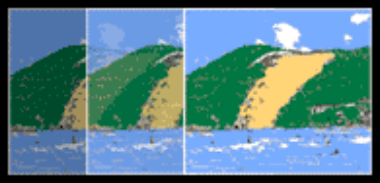
Pre-GPU Graphics Acceleration

- Integrated Graphics Architecture
- Silicon Graphics
- Evans & Sutherland



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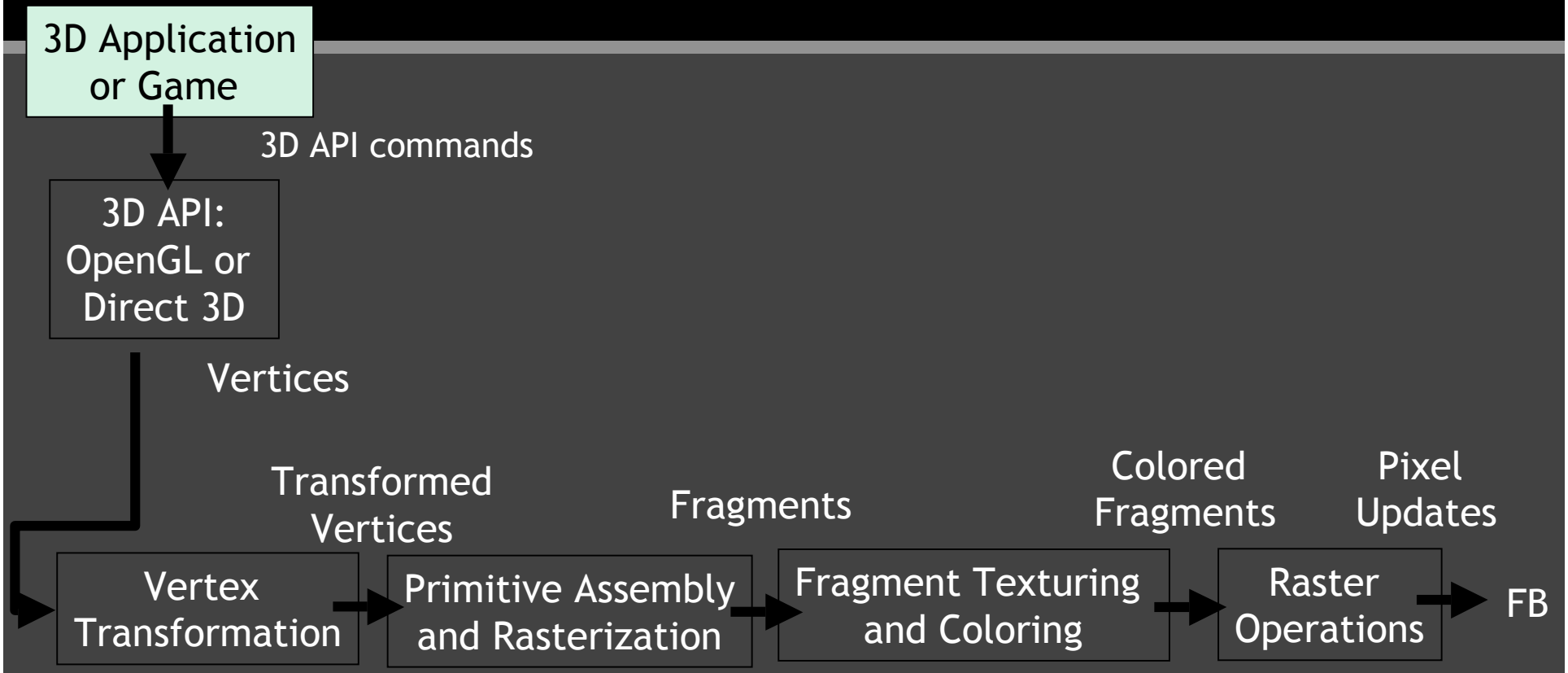
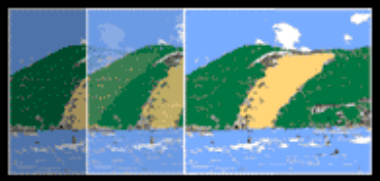
Graphics Pipeline





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Graphics Pipeline

3D Application or Game

3D API commands

```
glBegin(GL_TRIANGLES);
glVertex3f(0.0,0.0,0.0);
glVertex3f(1.0,0.0,0.0);
glVertex3f(0.5,1.0,0.0);
...
glEnd();
```

3D API: OpenGL or Direct 3D

Vertices

Vertex Transformation

Transformed Vertices

Primitive Assembly and Rasterization

Fragments

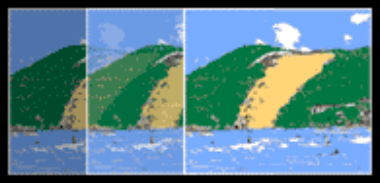
Fragment Texturing and Coloring

Colored Fragments

Raster Operations

Pixel Updates

FB



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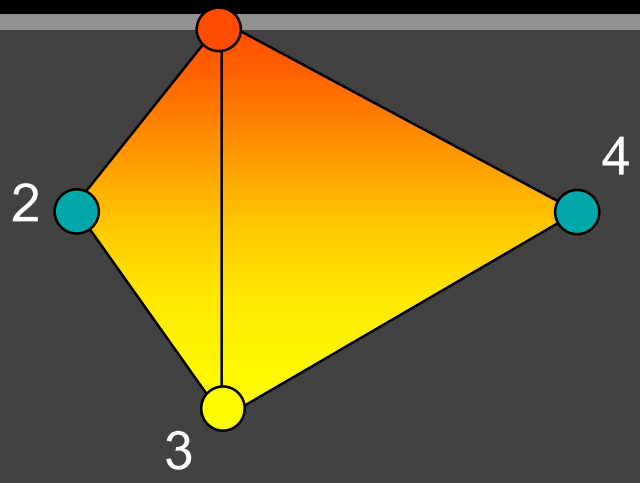


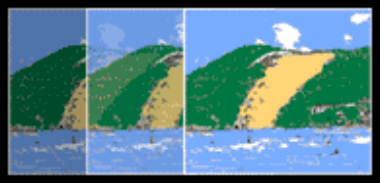
Transformed Vertices

Fragments

Colored Fragments

Pixel Updates

Vertex Transformation → Primitive Assembly and Rasterization → Fragment Texturing and Coloring → Raster Operations → FB



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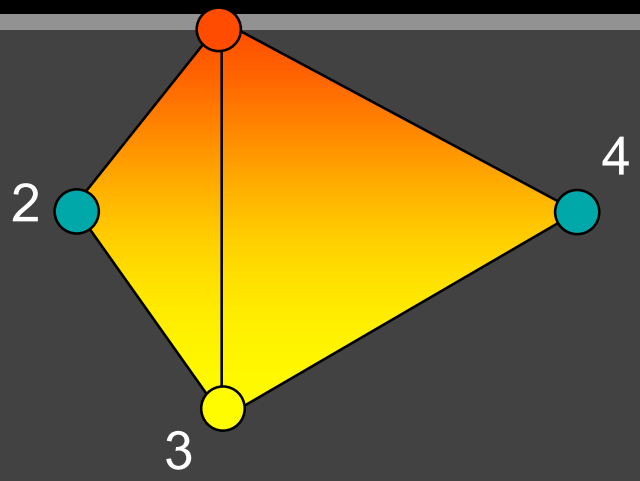
4 3 1 Vertices

1 2 3



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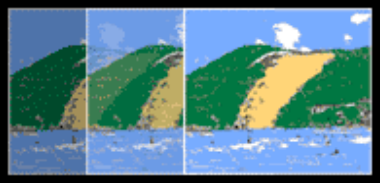

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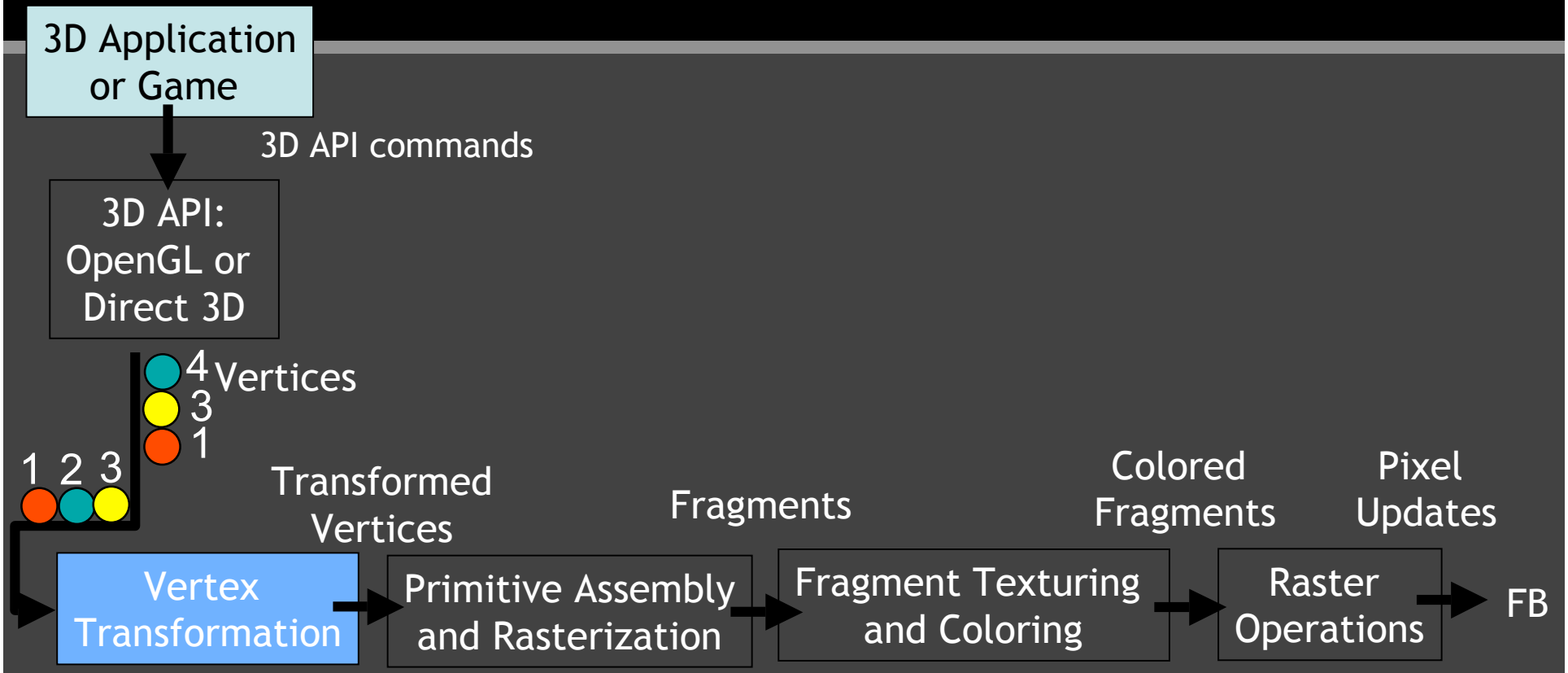
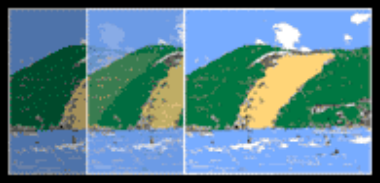
Graphics Pipeline





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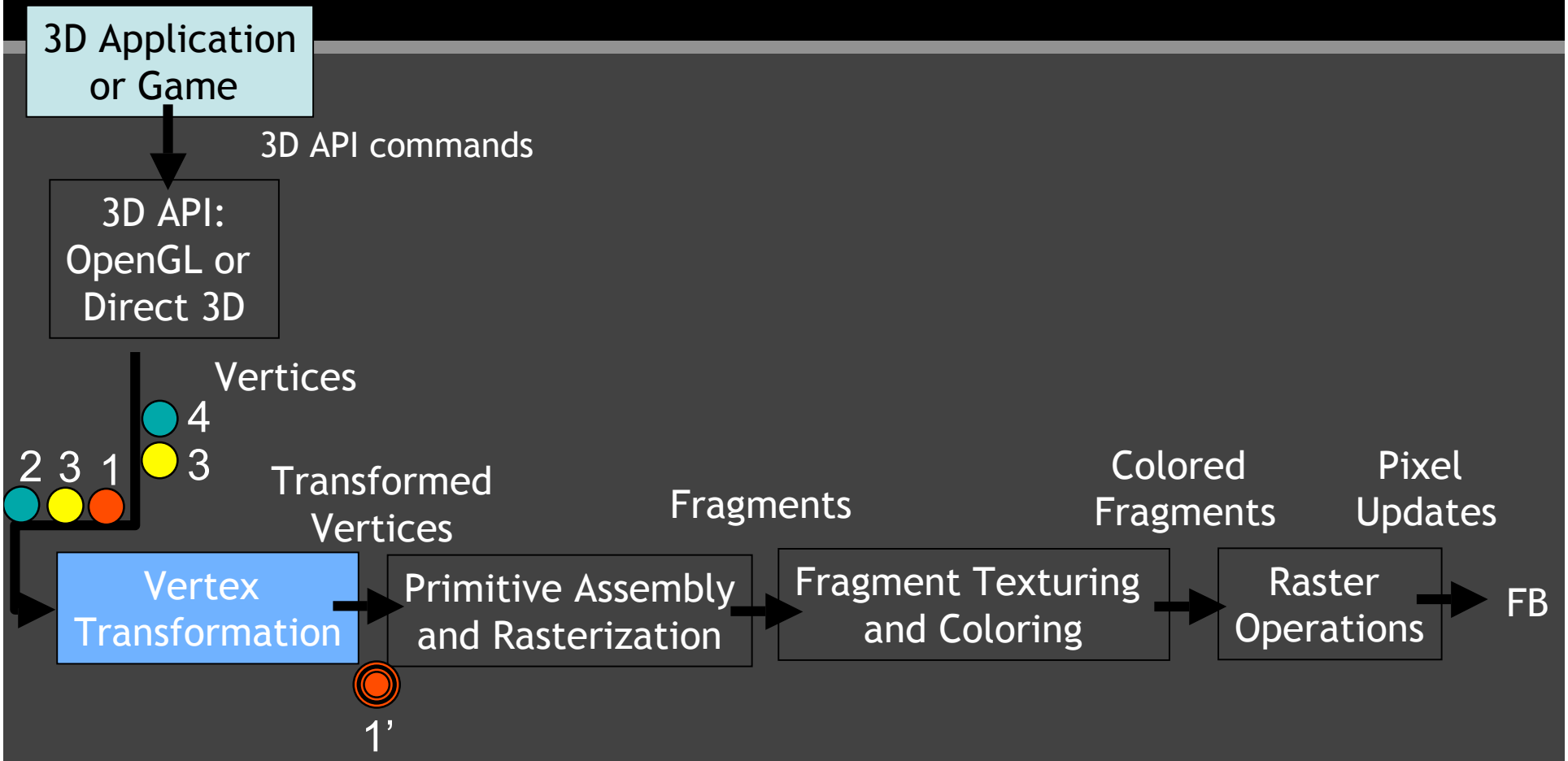

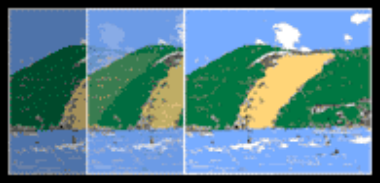

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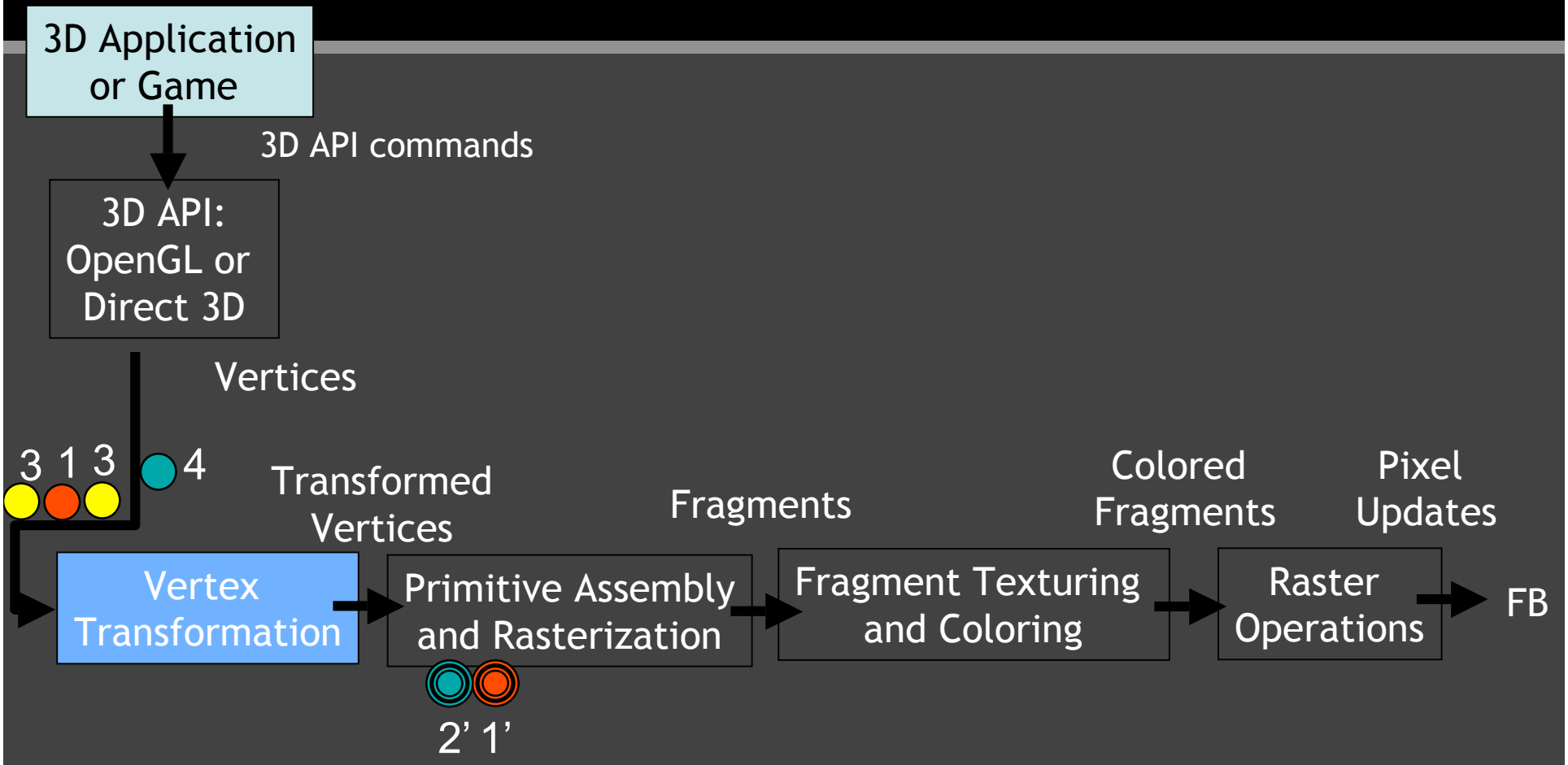

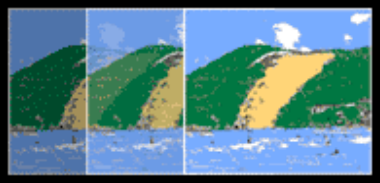

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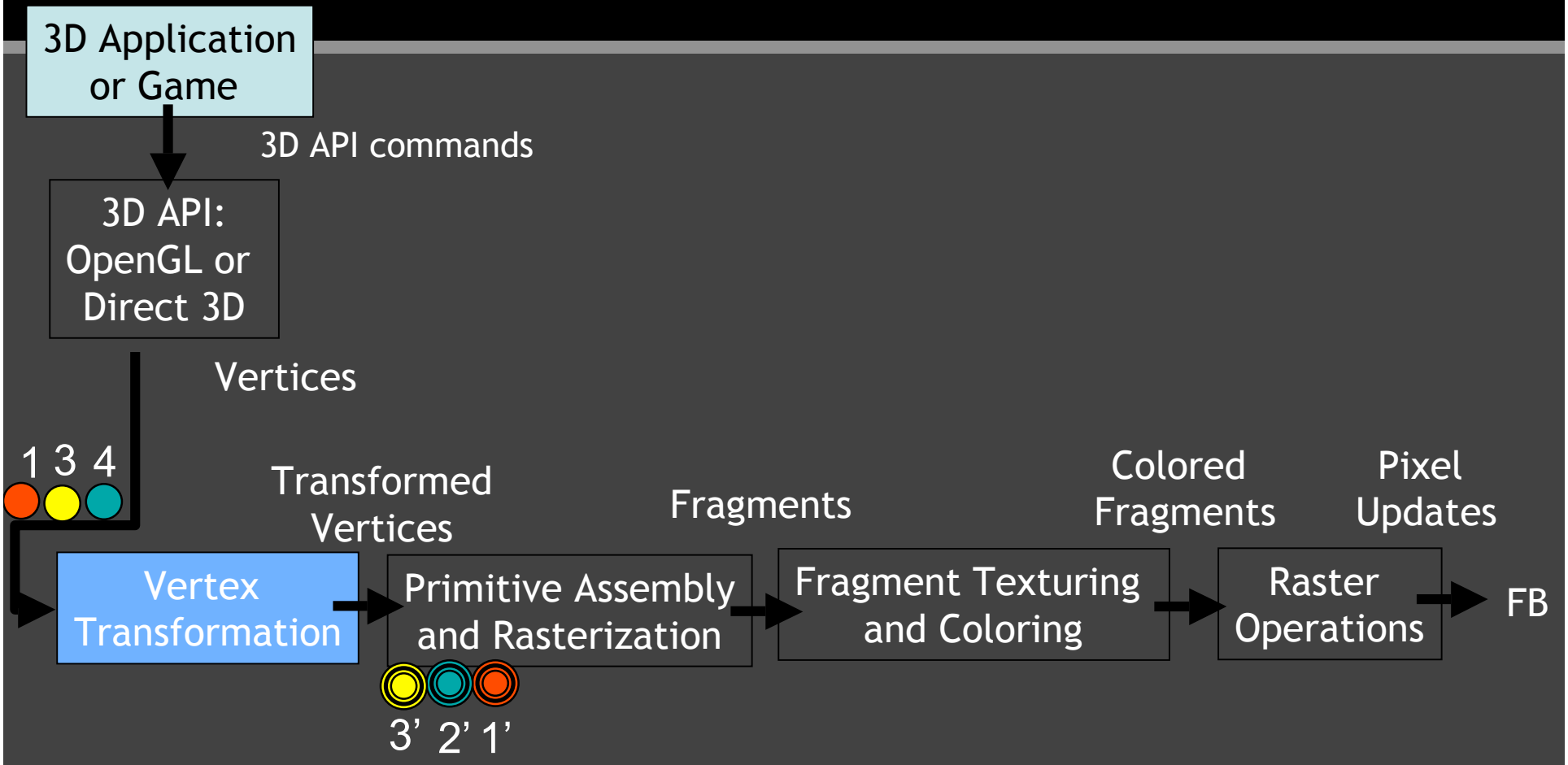

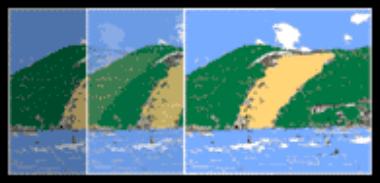

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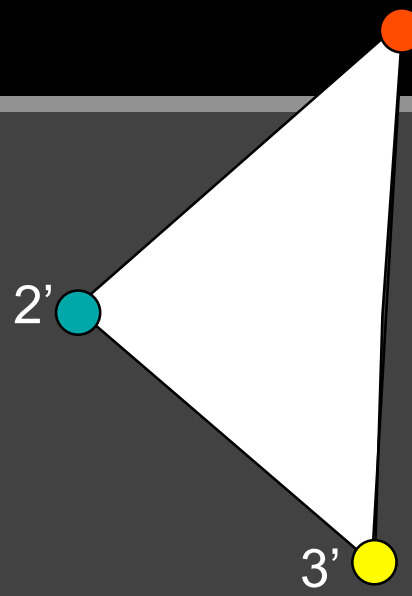

3D Application or Game

3D API commands

3D API: OpenGL or Direct 3D

Vertices

1 3 4

Transformed Vertices

Vertex Transformation

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Fragments

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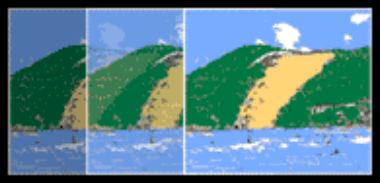
Colored Fragments

Raster Operations

Pixel Updates

FB



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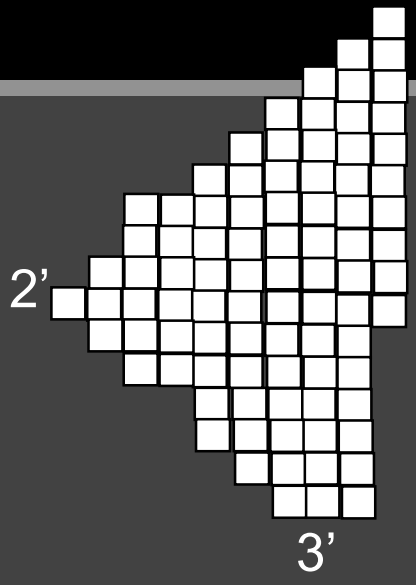

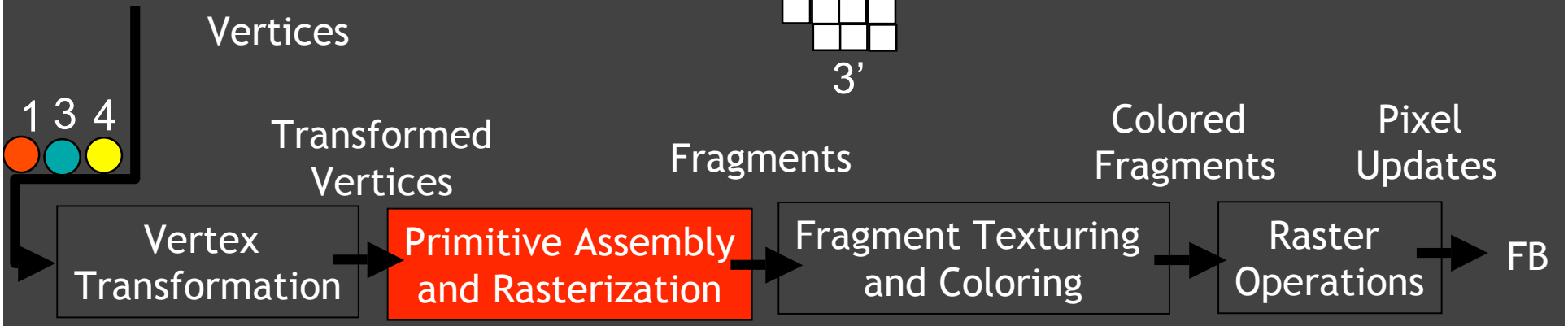

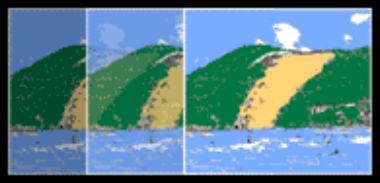

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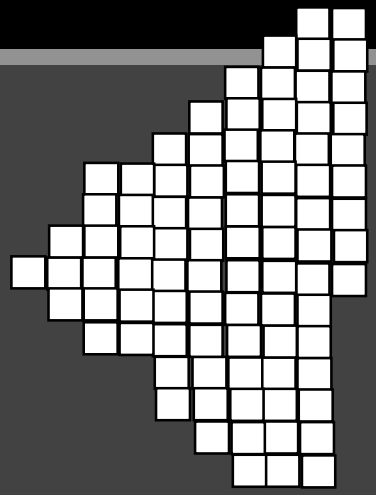

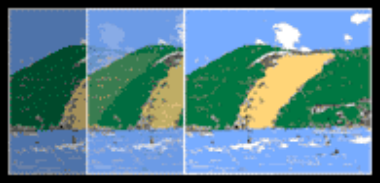

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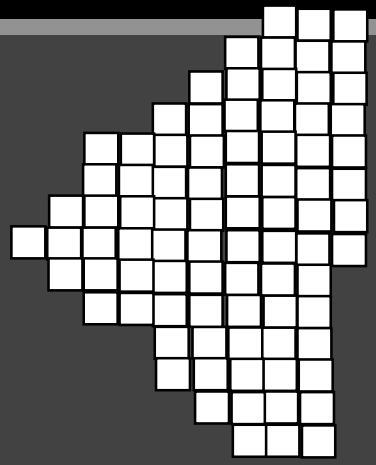

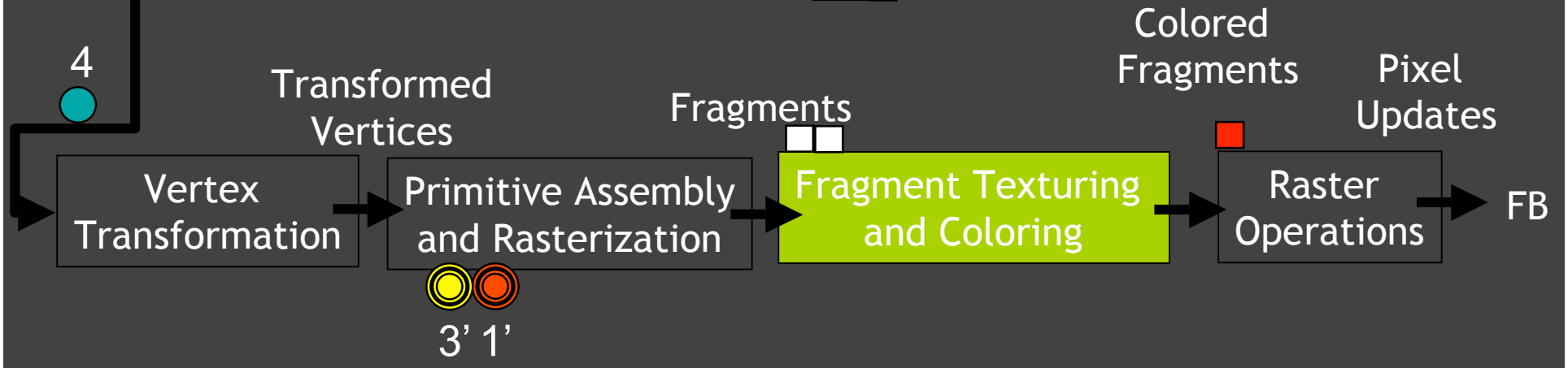

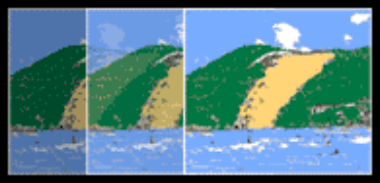

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Graphics Pipeline

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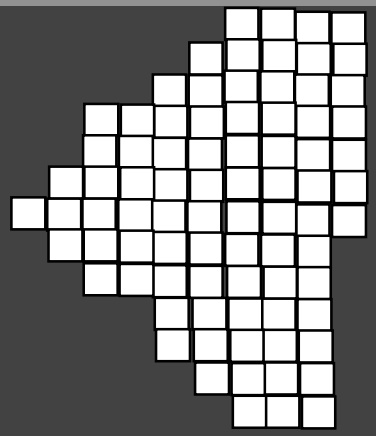

Transformed Vertices

Fragments

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Pixel Updates

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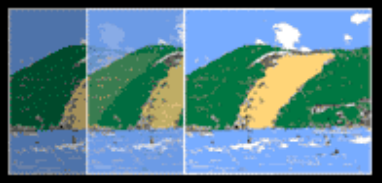
Fragment Texturing and Coloring

Raster Operations

FB

4’ 3’ 1’



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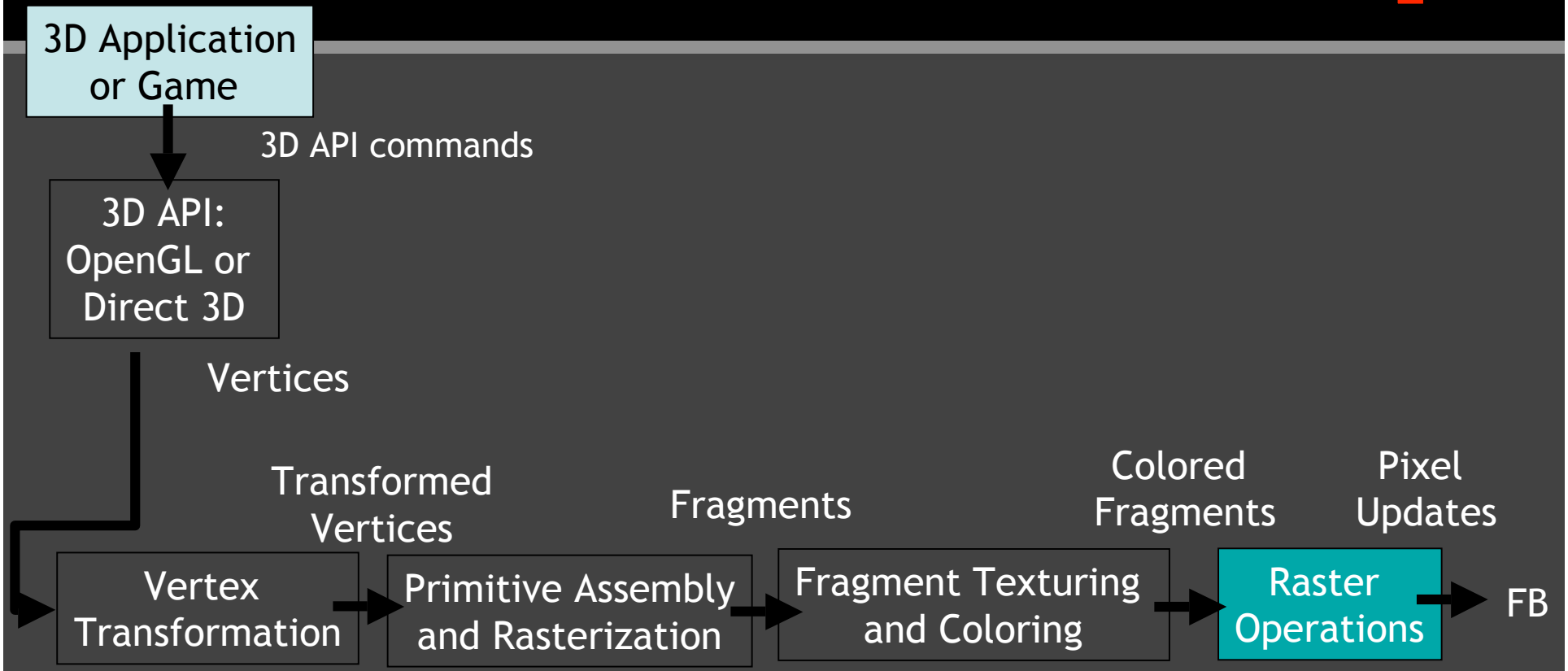

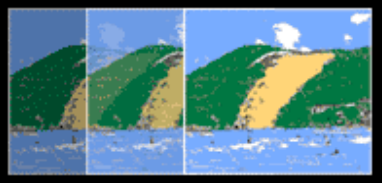

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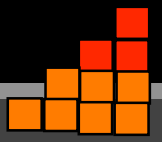

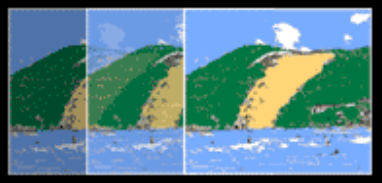

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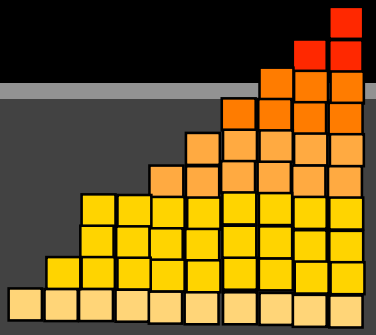

3D Application or Game

3D API commands

3D API: OpenGL or Direct 3D

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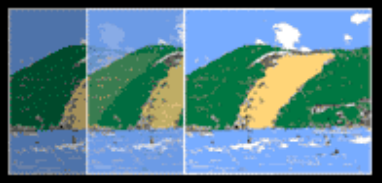
Vertex Transformation → Primitive Assembly and Rasterization → Fragment Texturing and Coloring → Raster Operations → FB



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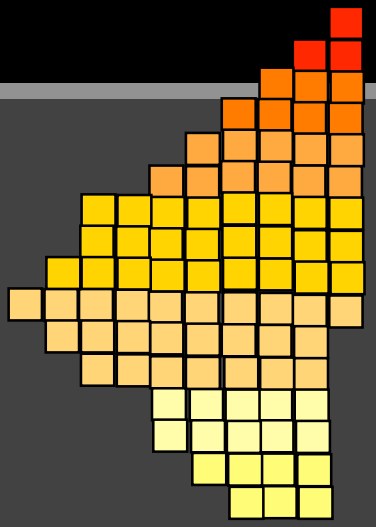

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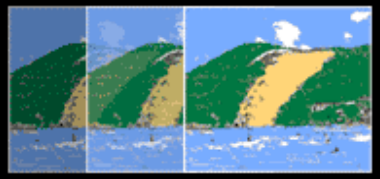

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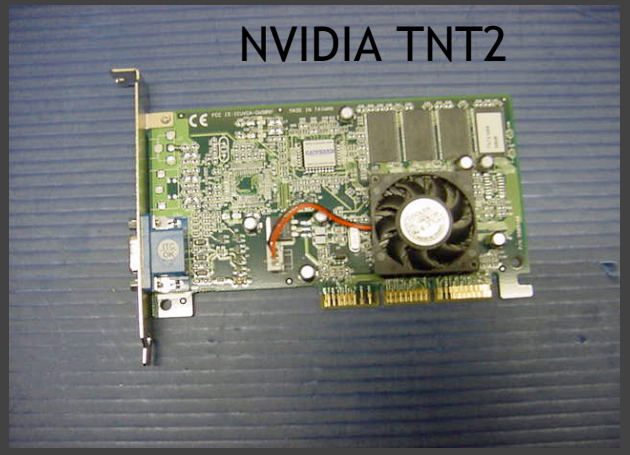
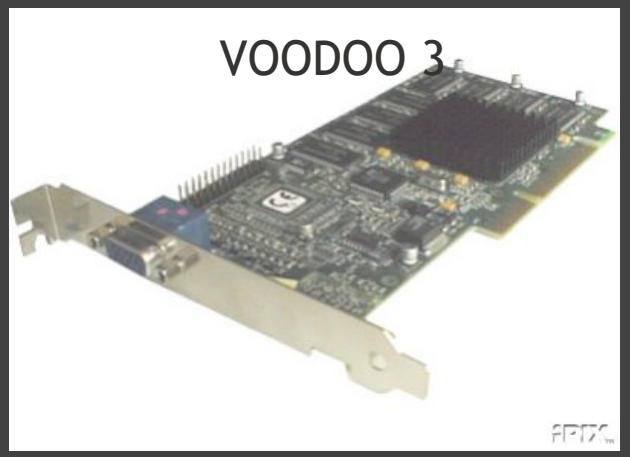
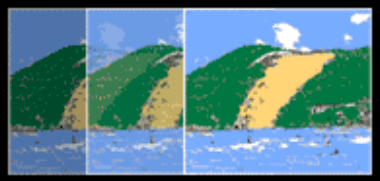
First-Generation GPUS (up to 1998)

- NVIDIA TNT2, ATI Rage, 3dfx Voodoo3
- Relevant tasks:
  - Rasterizing pre-transformed triangles
  - Applying one or two textures
  - Implement DirectX 6 feature set







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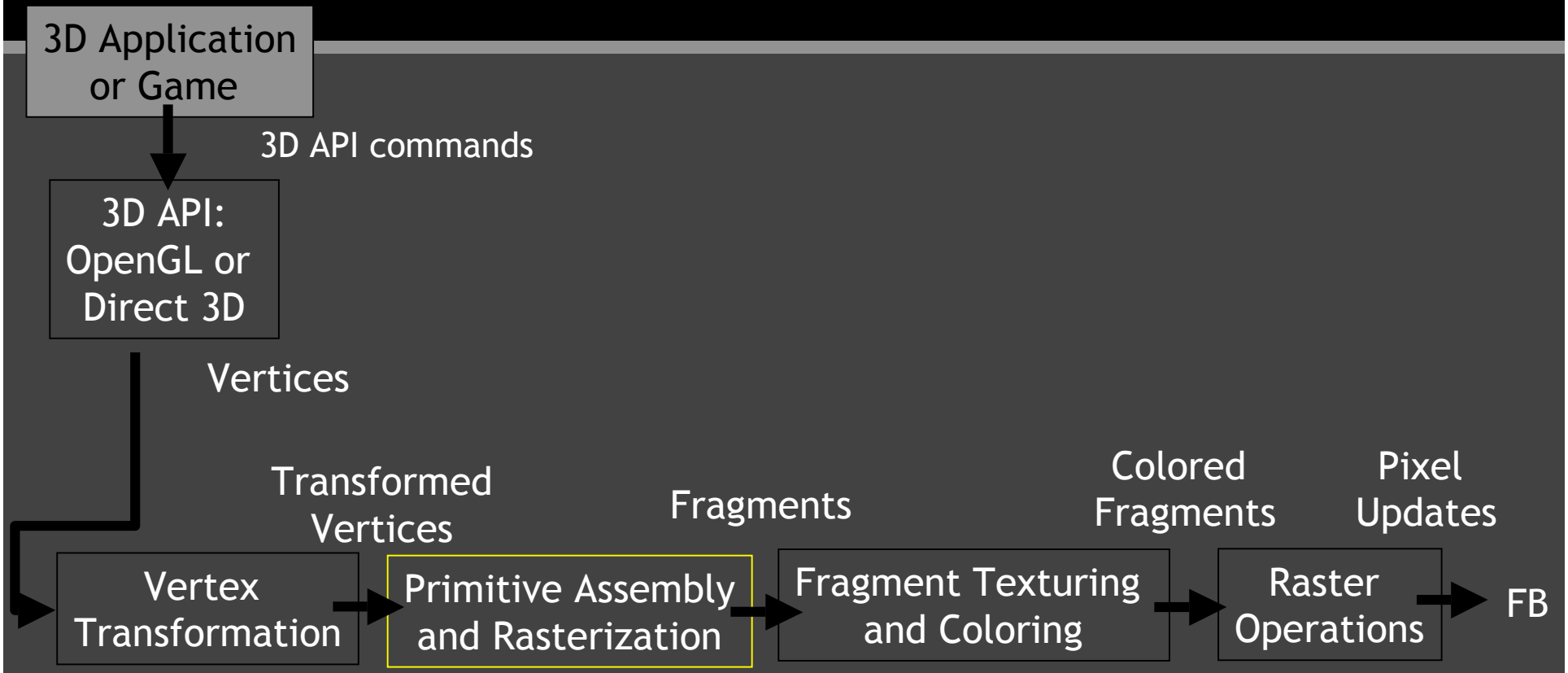
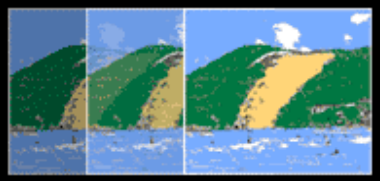
GPUs





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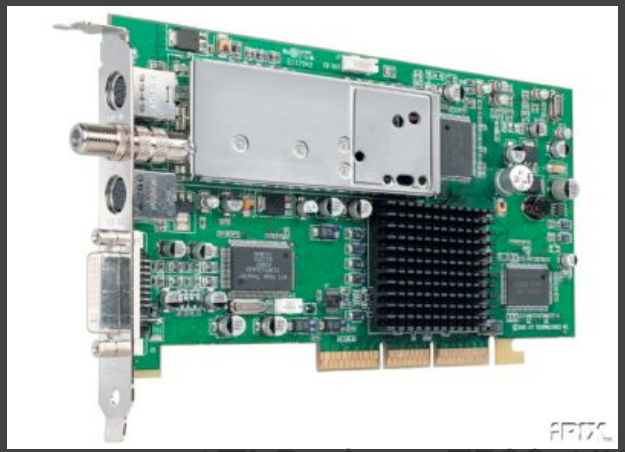
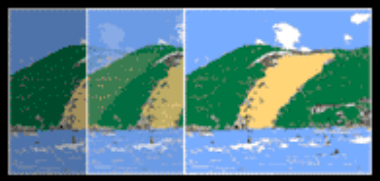
Second-Generation GPUS (1999-2000)

- NVIDIA GeForce 256, GeForce2, ATI Radeon 7500, S3 Savage 3D
- Relevant tasks:
  - Transformation & Lighting (T&L) em Hardware
  - Implement DirectX 7 feature set
  - Cube map textures
  - More math operations for combining textures (still limited)

GeForce2 GTS



ATI Radeon 7500 AIW



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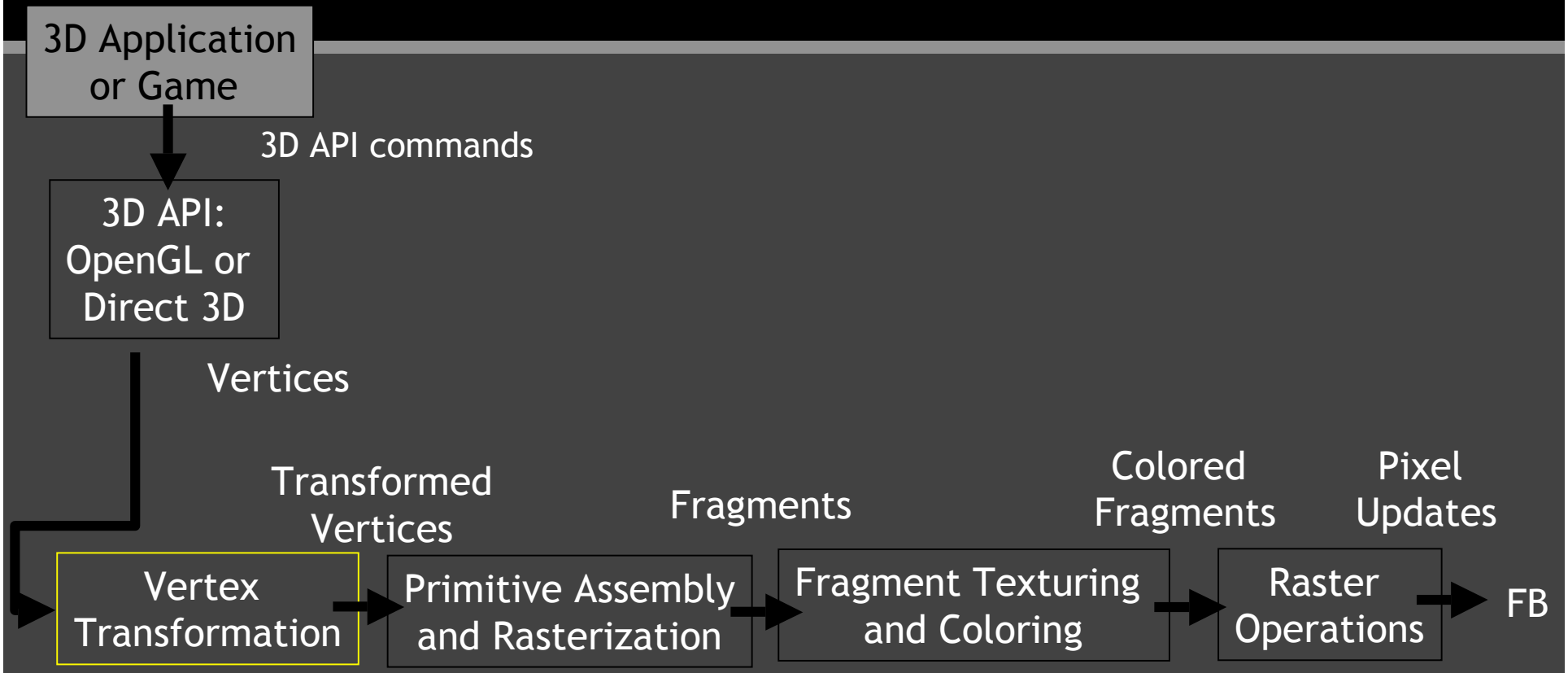
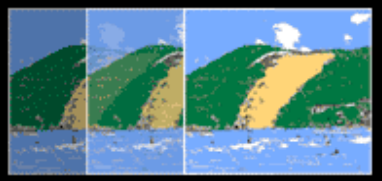
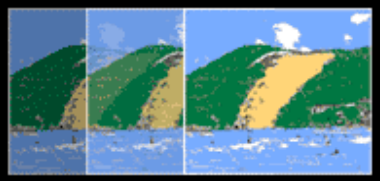
GPUs





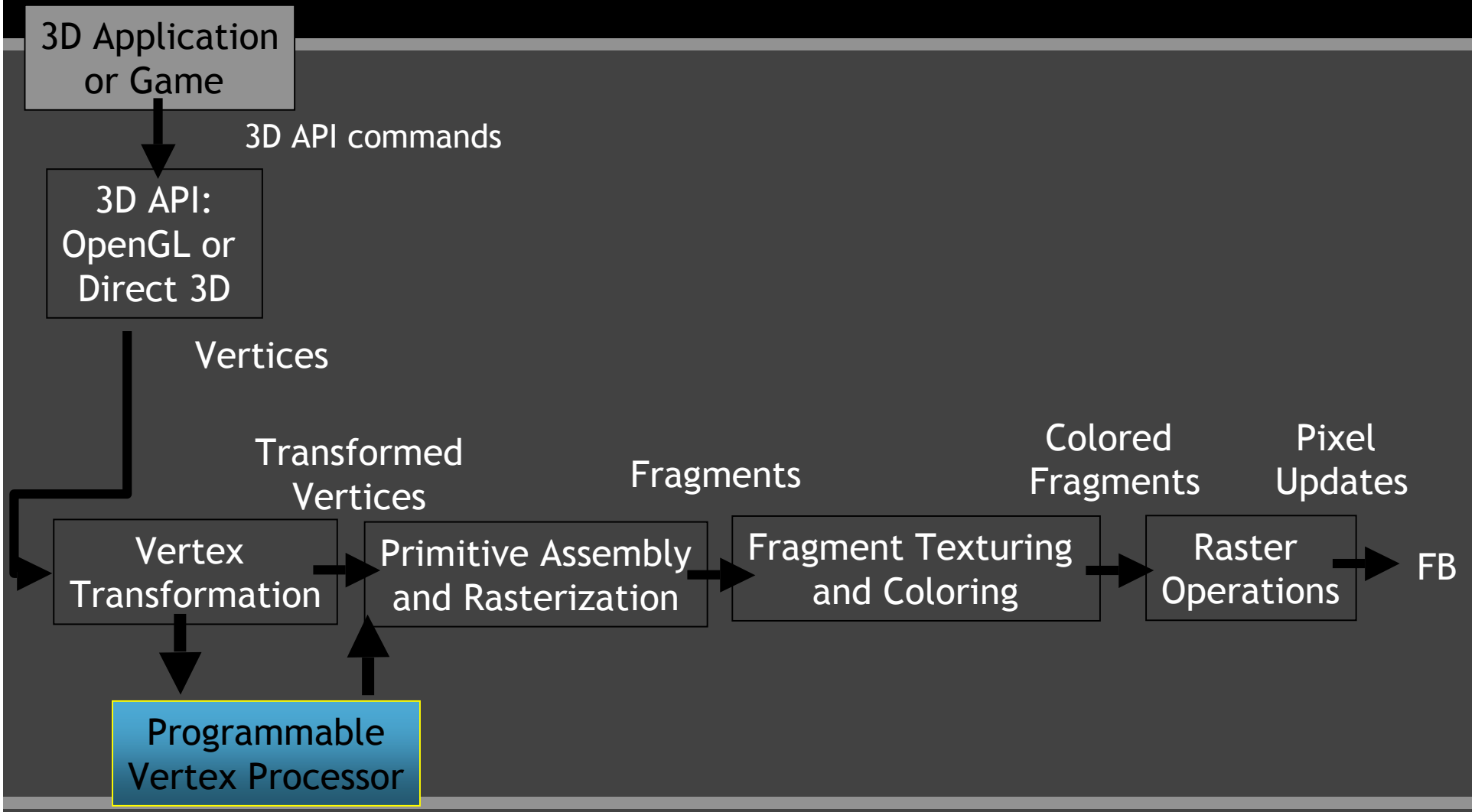
Third-Generation GPUS (2001)

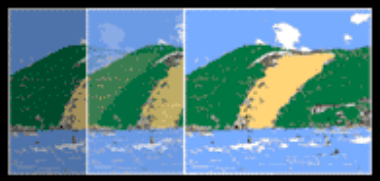
- NVIDIA GeForce 3, GeForce4 Ti, Microsoft XBox, ATI Radeon 8500, Quadro 4
- Relevant tasks:
  - Vertex programmability rather than more configurability
  - More pixel-level (fragment) configurability (not truly programmable)
  - 3D Textures
  - Shadow Maps



SIBGRAPI 2005

GPUs

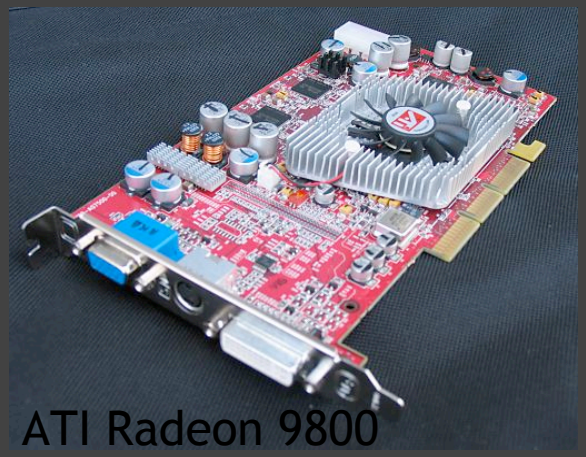




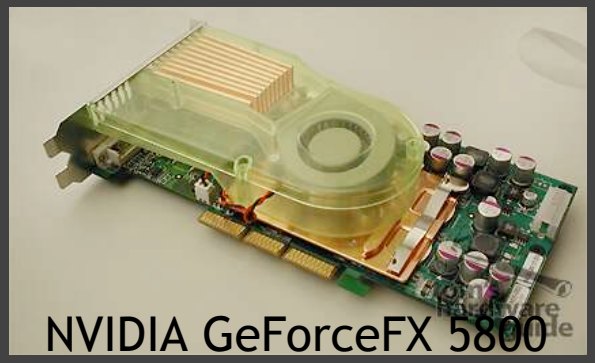
SIBGRAPI 2005

Fourth-Generation GPUS (2002-2003)

- NVIDIA GeForce FX family, ATI 9700, ATI 9800
- Relevant tasks:
  - Vertex and Fragment programmability
  - Implement DirectX 9 feature set
  - 32 Bit IEEE Floating Point per component (128-bit textures)



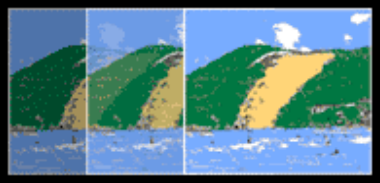
ATI Radeon 9800



NVIDIA GeForceFX 5800

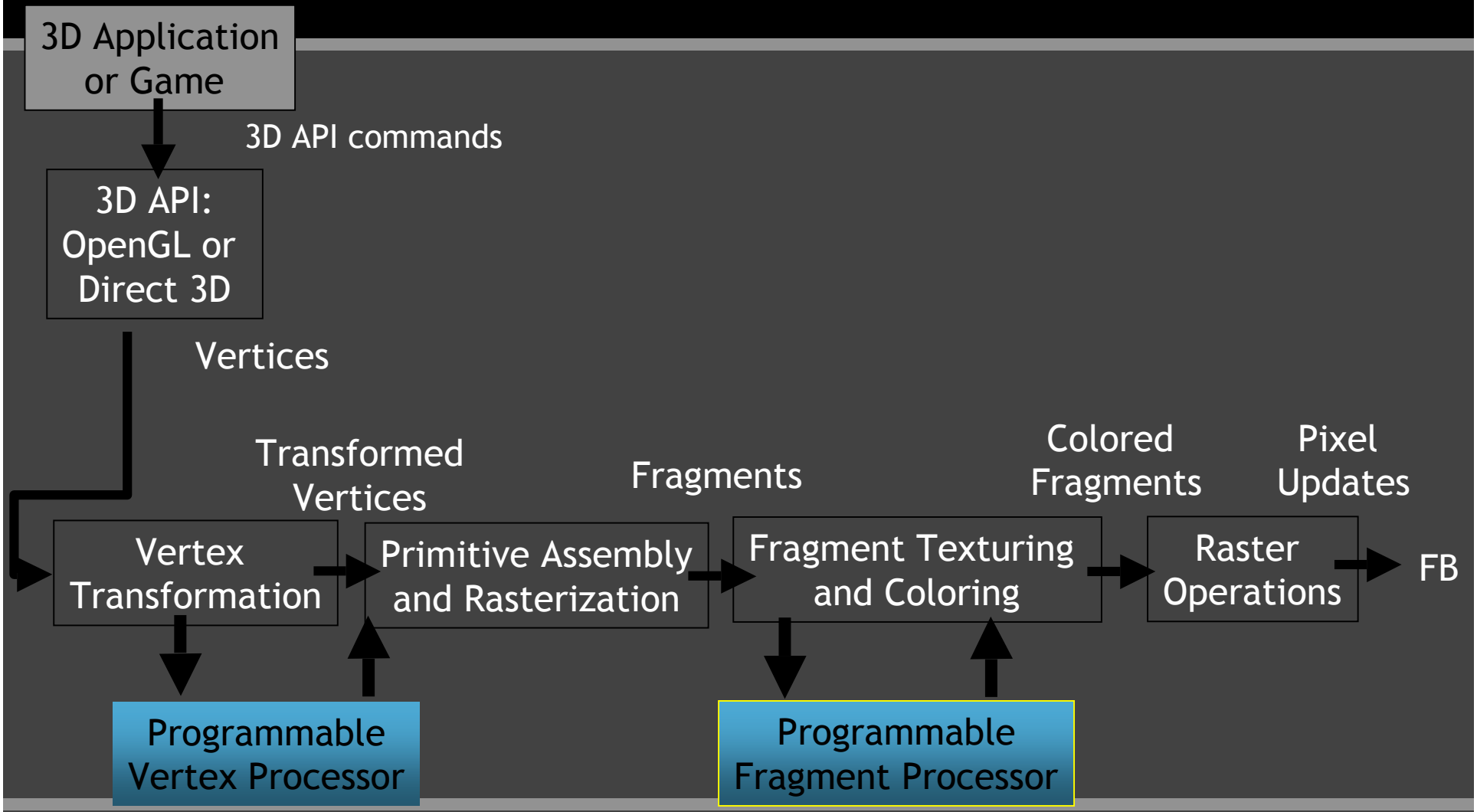
Intel Pentium 4 2.4 Ghz = 55 million transistors
NVIDIA GeForce FX 5800 = 125 million transistor

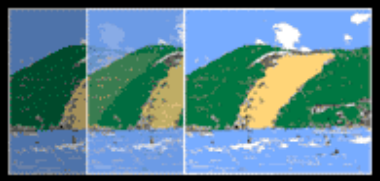
2.27



SIBGRAPI 2005

GPUs

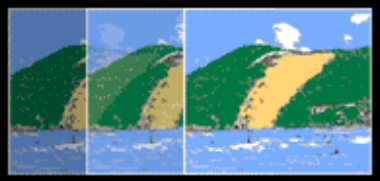




SIBGRAPI 2005

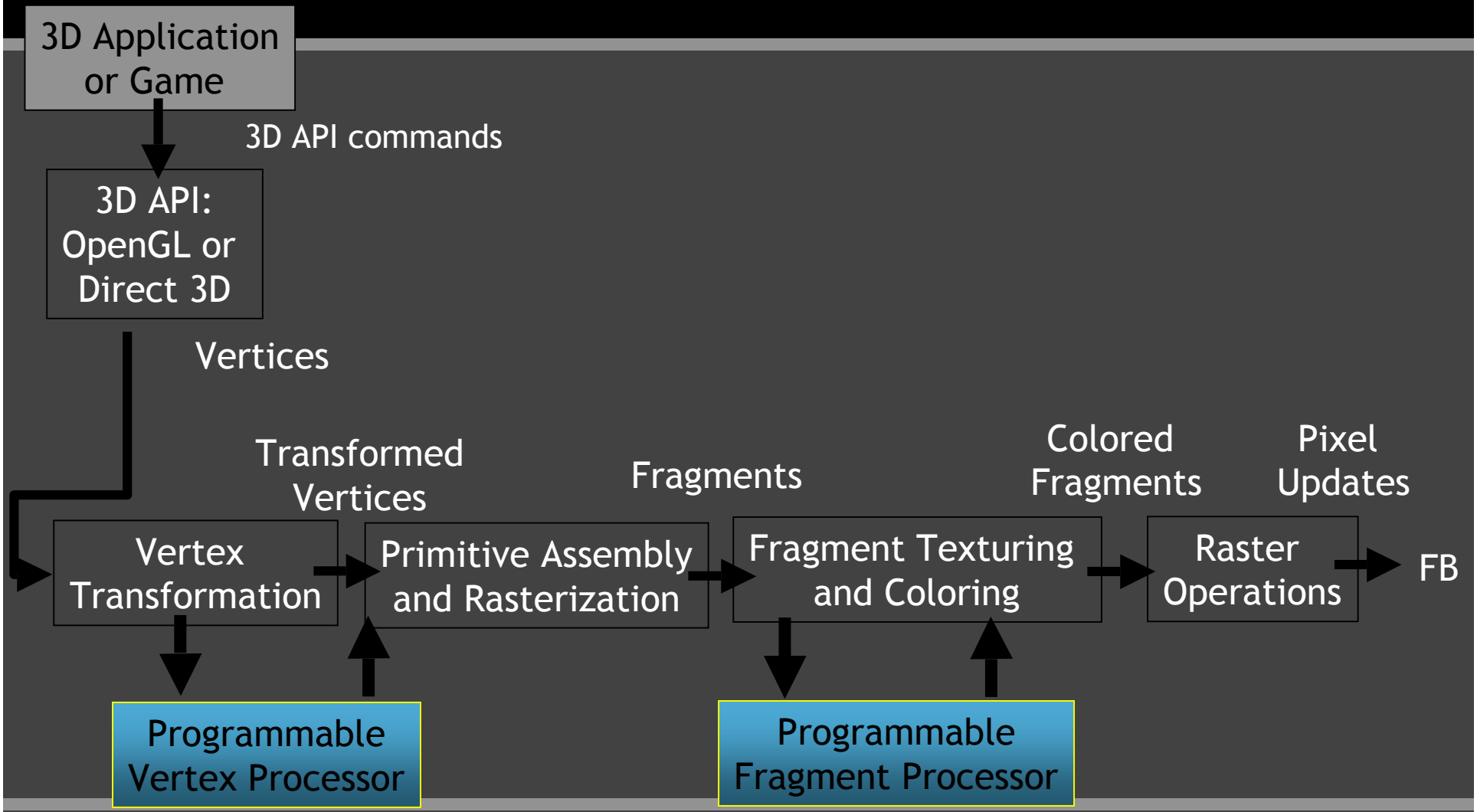
Fifth Generation (04-05)

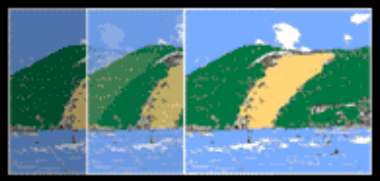
- NVIDIA 6800
  - 16 pipes fragment shader
- NVIDIA 7800:
  - 24 pipes fragment shader
- ATI X1800 (released 4 days ago)
- What is has to offer:
  - Memory access for vertex programs
  - Branches in fragment program
  - Longer fragment programs



SIBGRAPI 2005

GPUs





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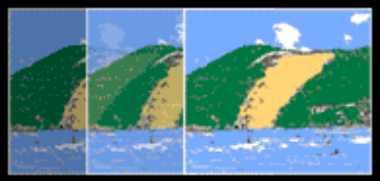
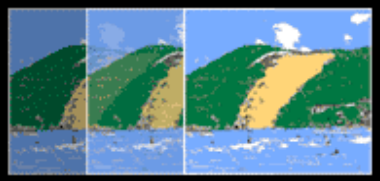
Sixth Generation (2006)

- Unified Architecture:
  - Same Instruction Set (Vertex and Fragment Processors)
  - Geometry Processor:
    - Ability to program how vertices can be combined to form new primitives
    - Ability to create vertices
  - Generalized Output Buffers
  - More ?



What the GPU offers ?

- Streaming processors
- Vector operations:
  - 4-component instructions with 32-bit IEEE floating point operations
- GPU Memory Accesses through Textures:
  - 1-,2-,3-D tables
  - no read-write textures
- Multiple Render Targets
- Limited branching/loops



SIBGRAPI 2005

What we will see today

- Summary of solutions for Volume Rendering problems using GPUs
- Span different architectures
- Open exciting perspectives for other interesting problems:

Dynamic or Time-Varying Problems