Introdução às GPUs

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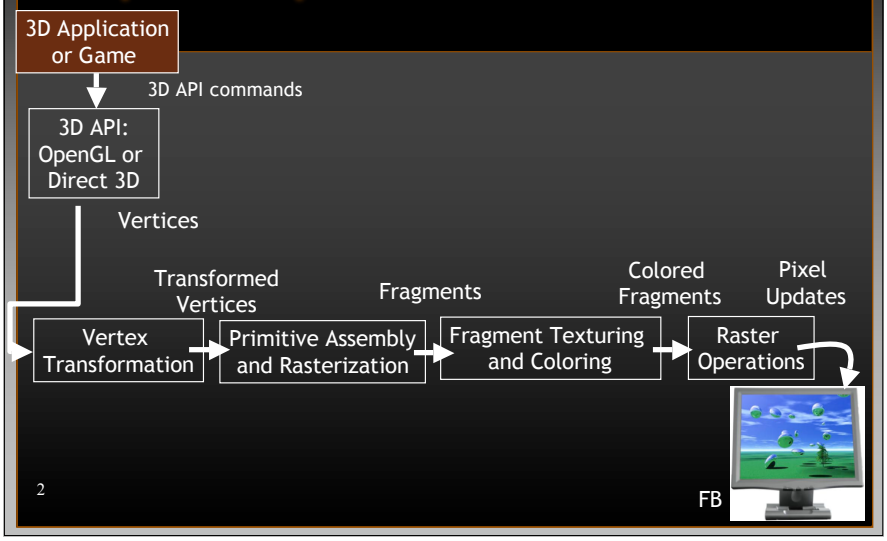
UFPE

atualização/maio 2009

Graphics Pipeline



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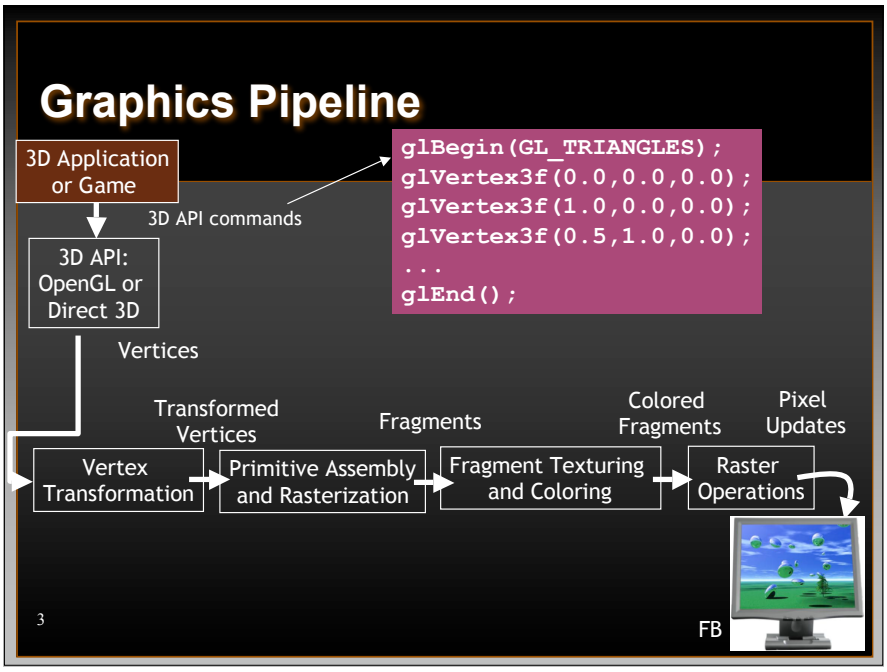
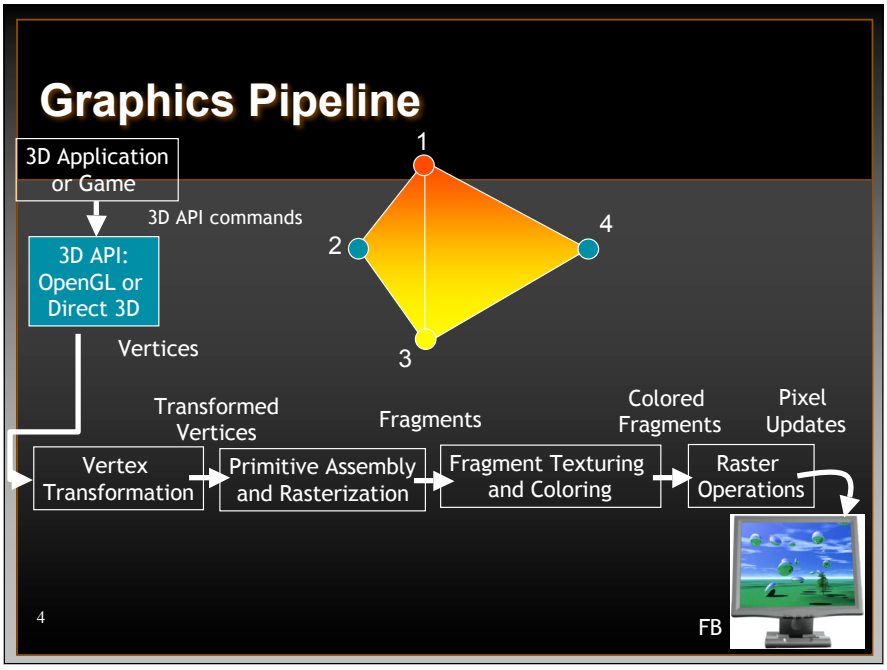
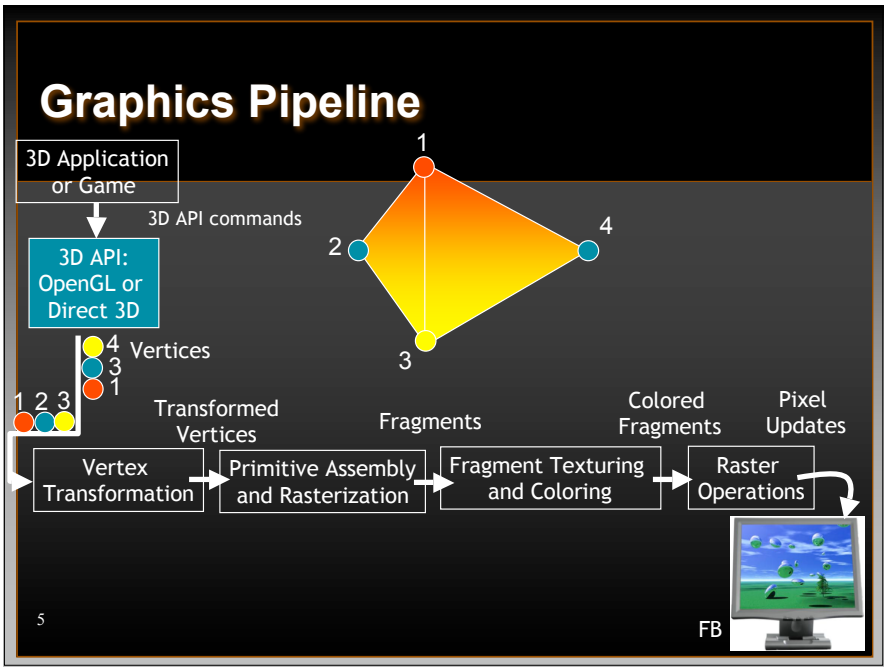

Graphics Pipeline
3D Application or Game
3D API commands
glBegin(GL_TRIANGLES);
glVertex3f(0.0,0.0,0.0);
glVertex3f(1.0,0.0,0.0);
glVertex3f(0.5,1.0,0.0);
...
glEnd();
3D API: OpenGL or Direct 3D
Vertices
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
FB
3


Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
1
2
3
4
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
FB
4


Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
4
3
1
Vertices
1 2 3
1
2
3
4
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
FB
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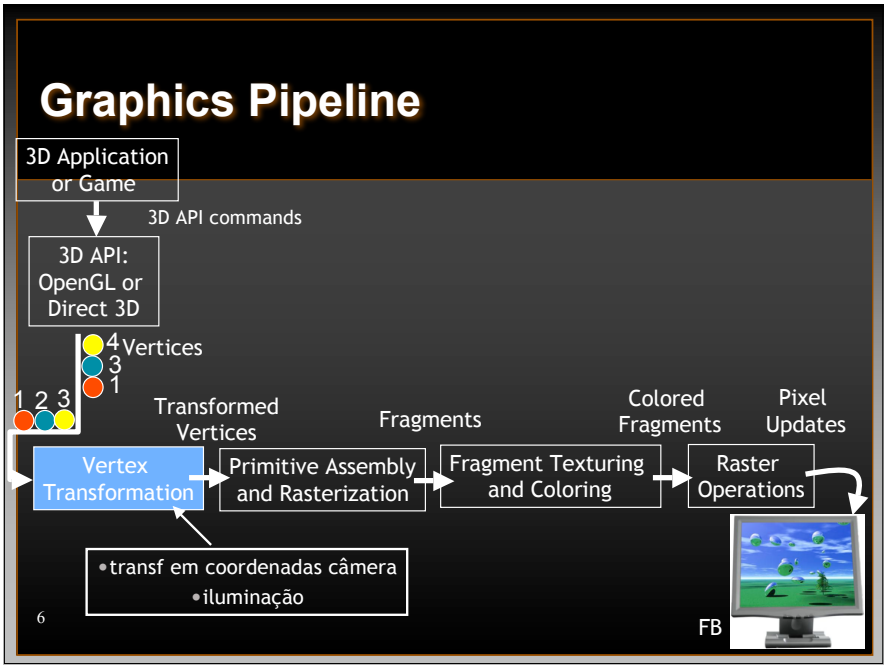
Graphics Pipeline
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3D API commands
3D API: OpenGL or Direct 3D
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3
1
Vertices
1 2 3
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
•transf em coordenadas câmera
•iluminação
FB
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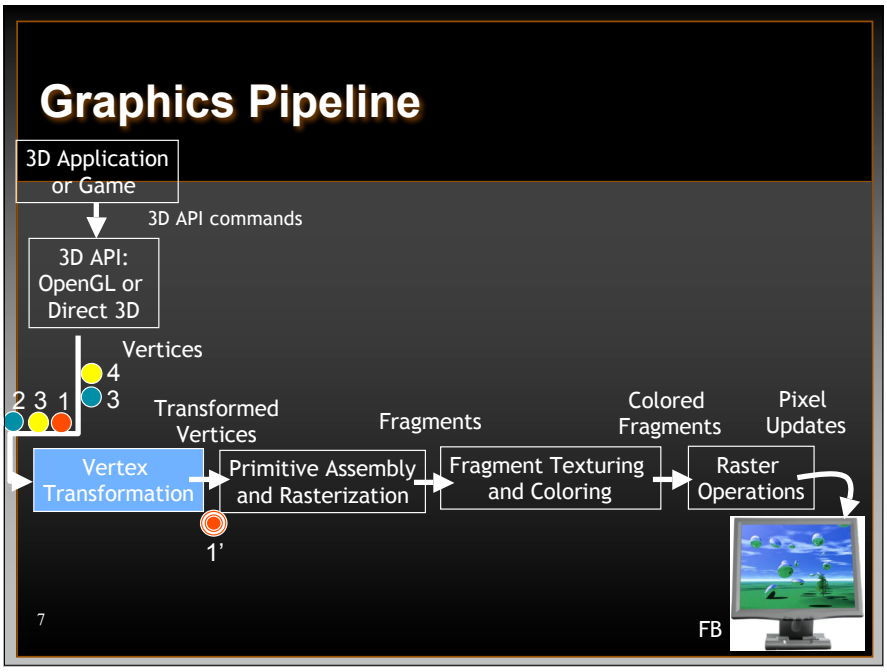
Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
4
3
2 3 1
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
1'
FB
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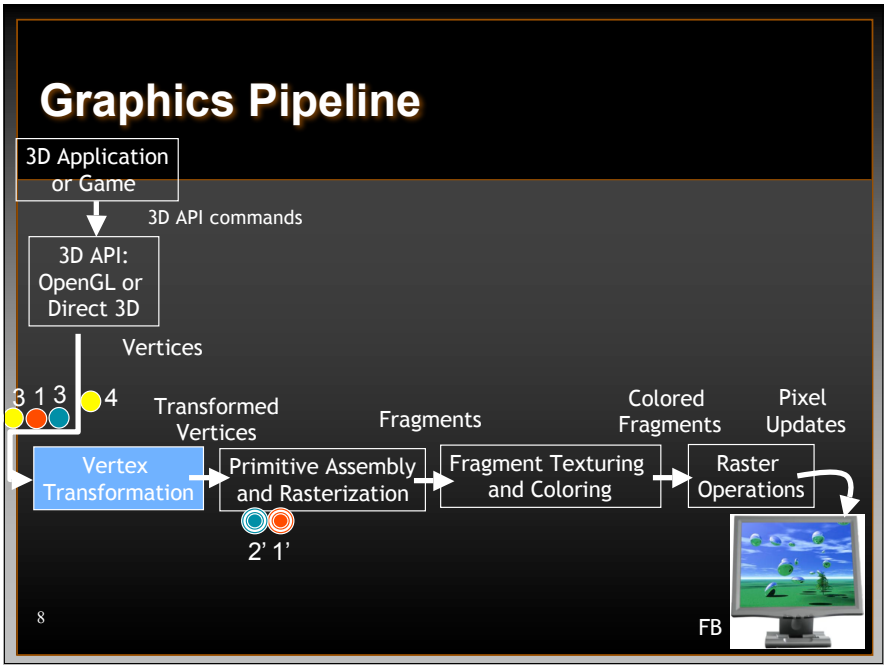
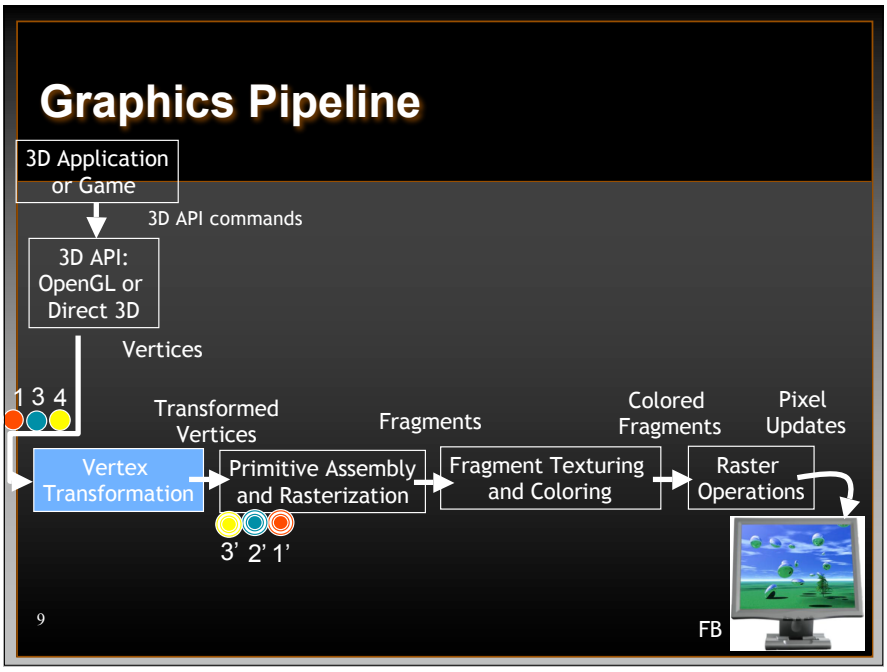

Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
3 1 3
4
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
2' 1'
FB
8


Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
1 3 4
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
3' 2' 1'
FB
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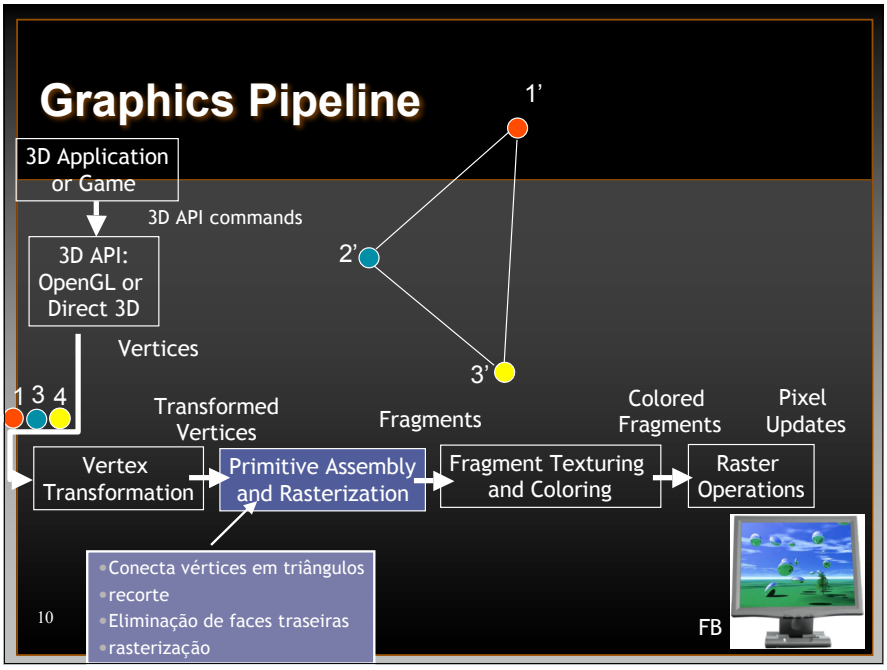
Graphics Pipeline
1'
2'
3'
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
1 3 4
Transformed Vertices
Fragments
Colored Fragments
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Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
Conecta vértices em triângulos
recorte
Eliminação de faces traseiras
rasterização
FB
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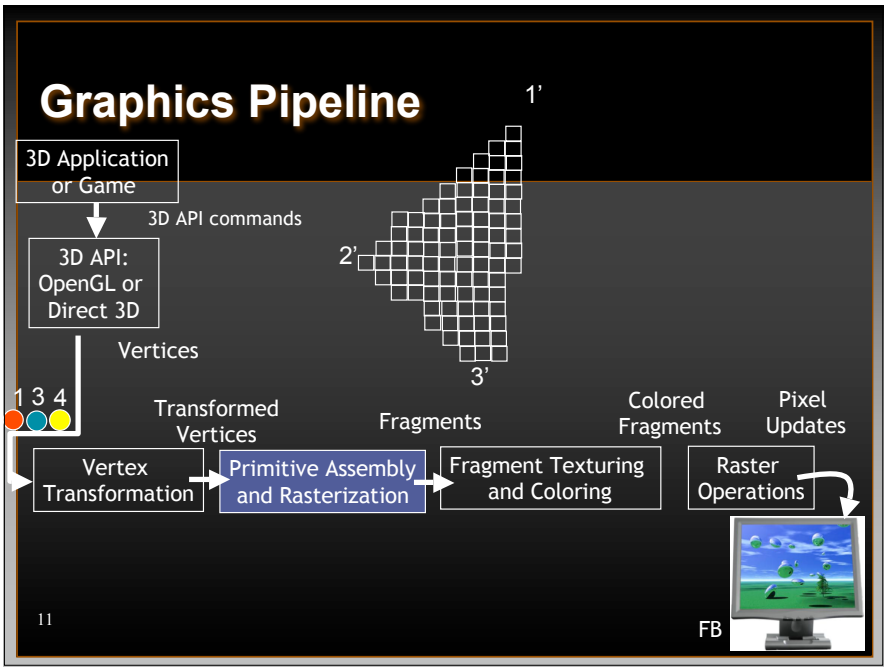
Graphics Pipeline
1'
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
2'
Vertices
3'
1 3 4
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
FB
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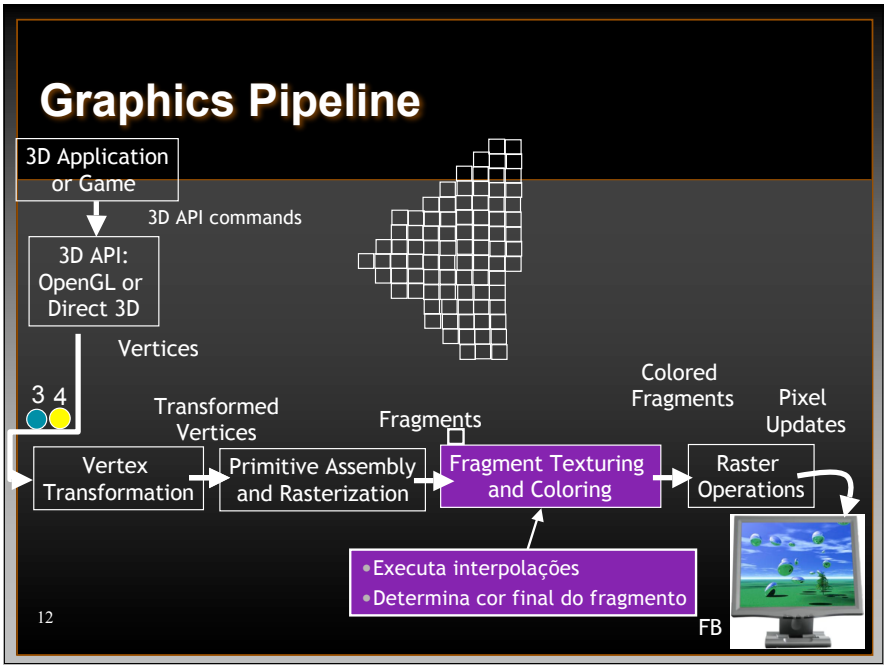
Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
3 4
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
•Executa interpolações
•Determina cor final do fragmento
FB
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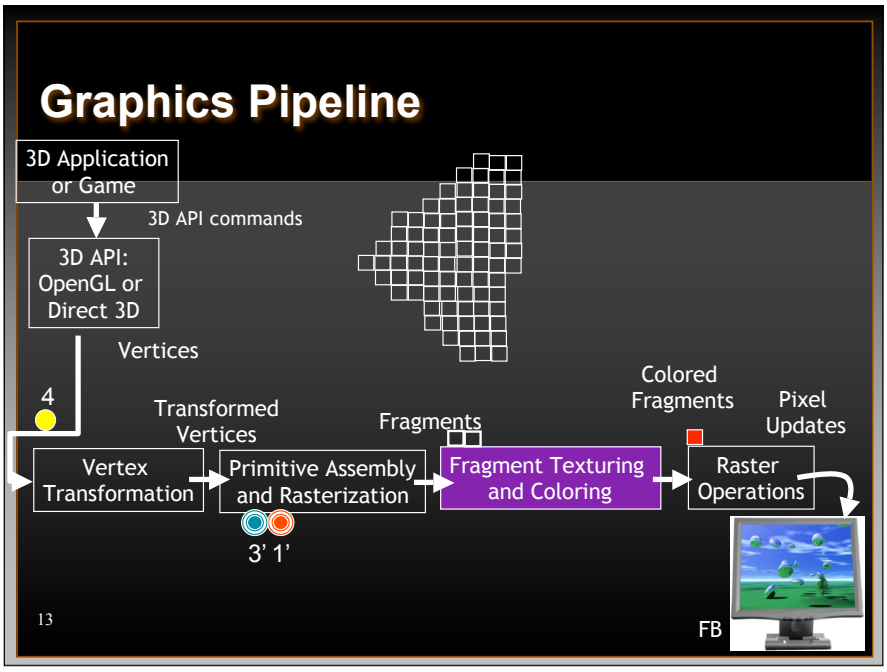
Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
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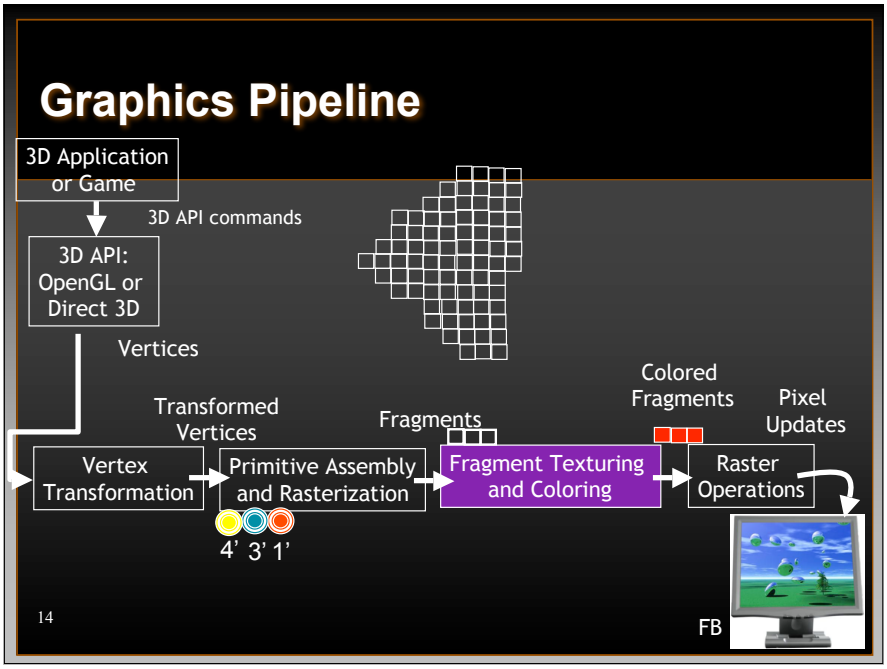
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
3' 1'
13
FB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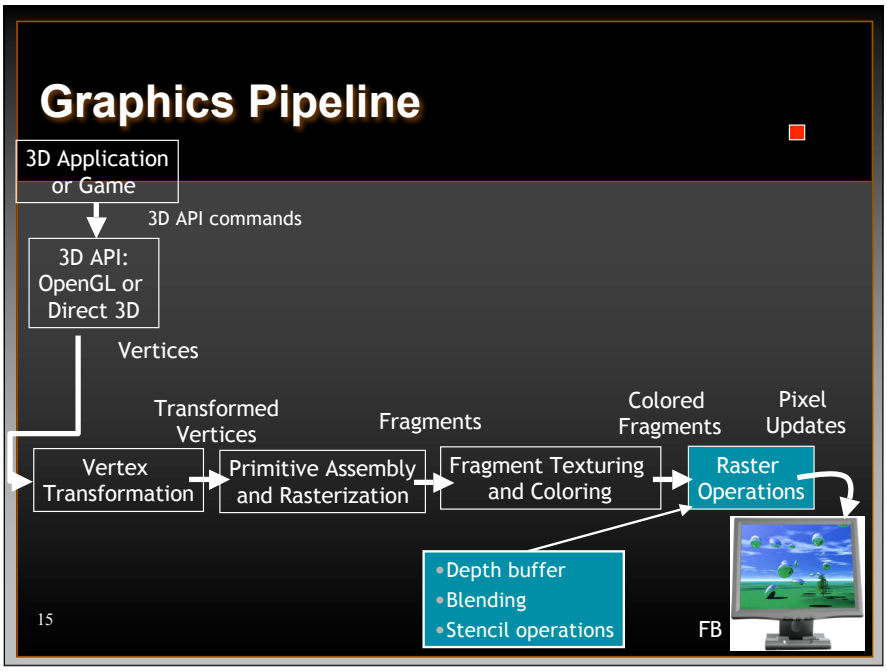
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
4' 3' 1'
14
FB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Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
Depth buffer
Blending
Stencil operations
FB
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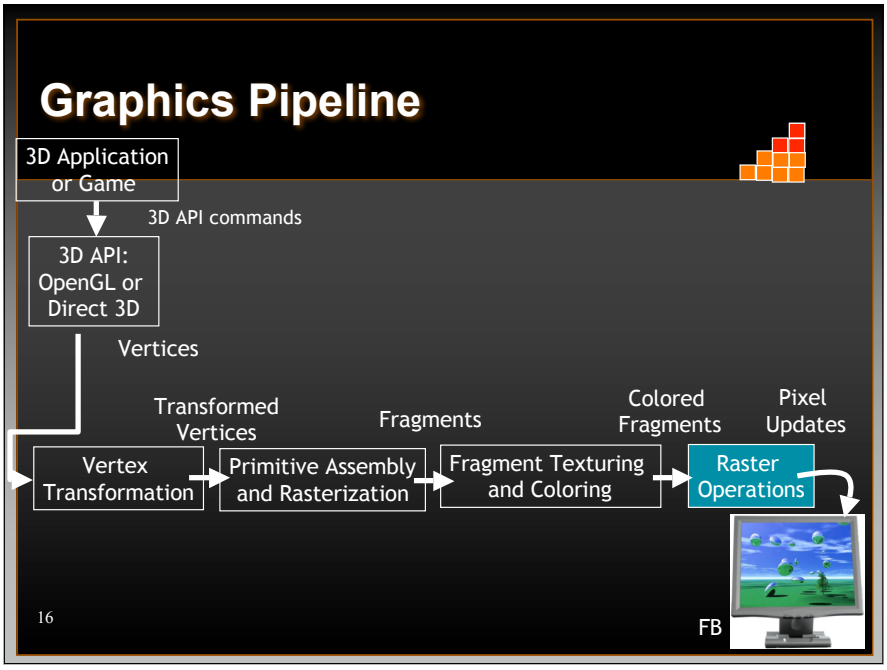
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Vertices
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
FB
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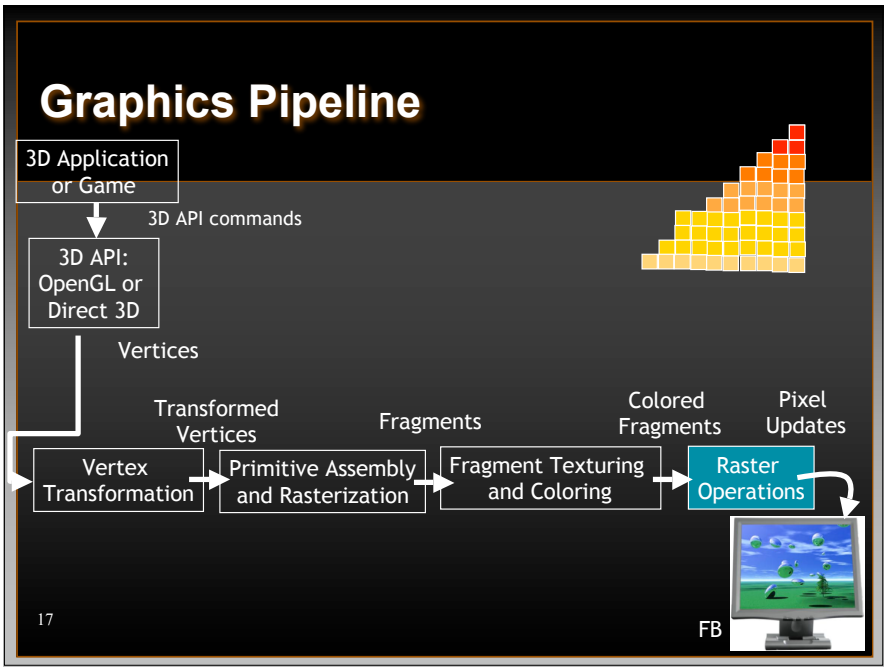
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FB
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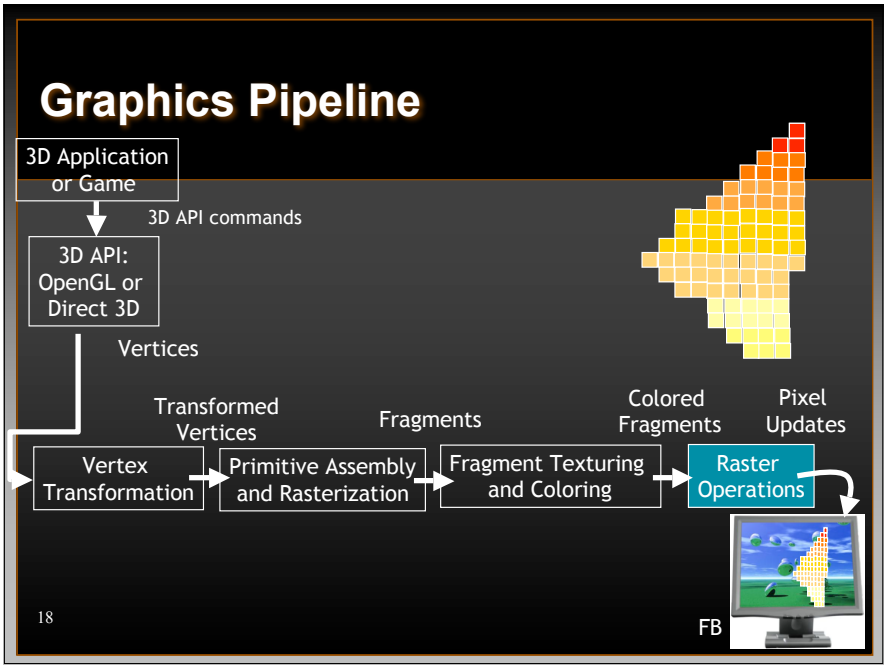
Graphics Pipeline
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Vertices
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Pixel Updates
Vertex Transformation
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Fragment Texturing and Coloring
Raster Operations
FB
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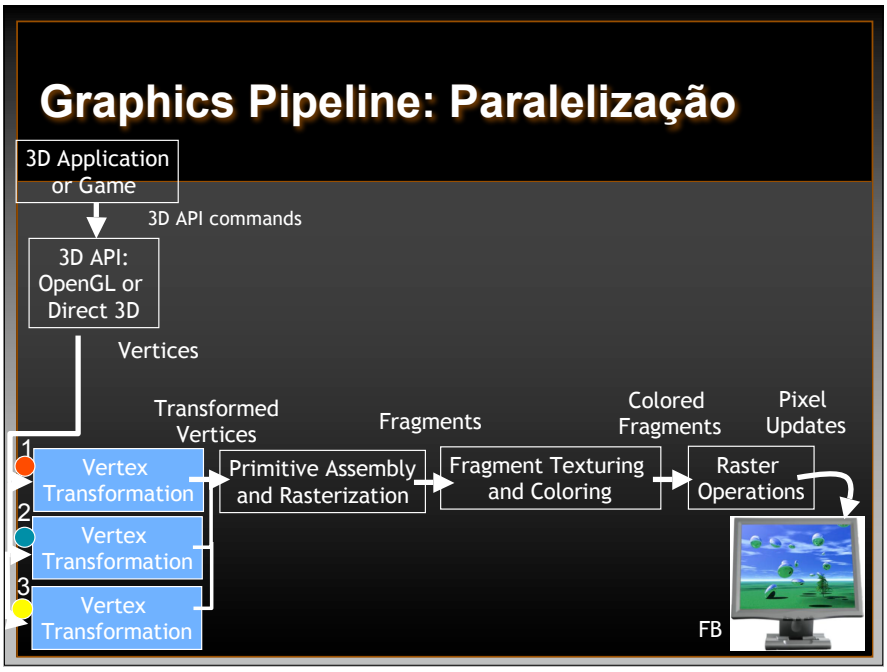
Graphics Pipeline: Paralelização
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
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2
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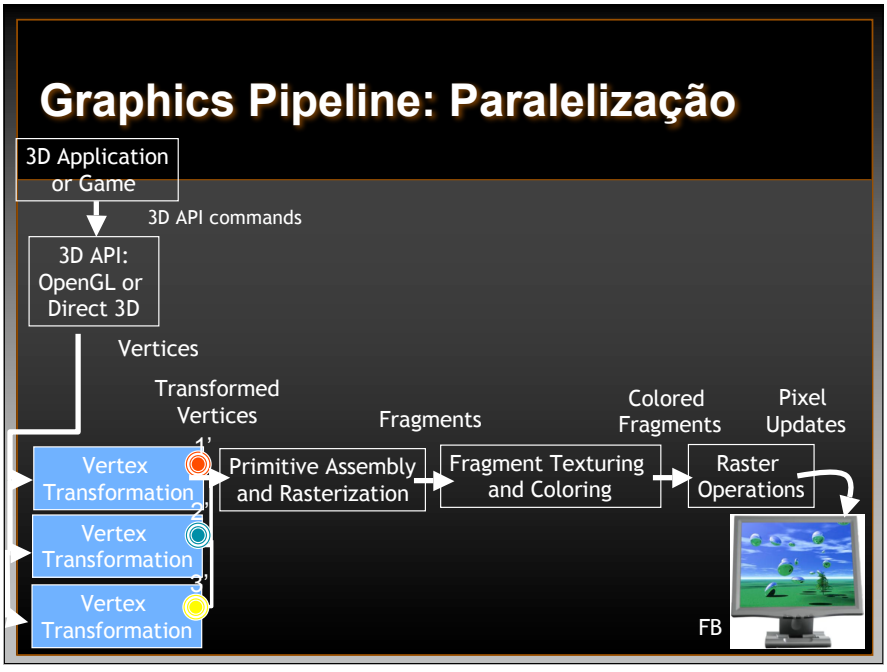
Vertex Transformation
Vertex Transformation
Vertex Transformation
Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
FB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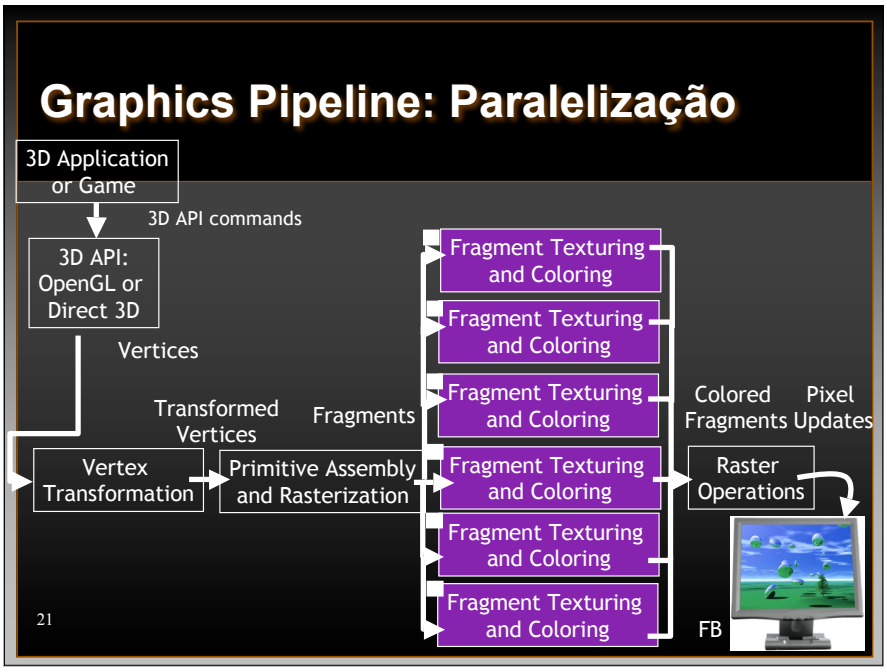
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Fragment Texturing and Coloring
Fragment Texturing and Coloring
Fragment Texturing and Coloring
Fragment Texturing and Coloring
Fragment Texturing and Coloring
Colored Fragments
Pixel Updates
Raster Operations
FB
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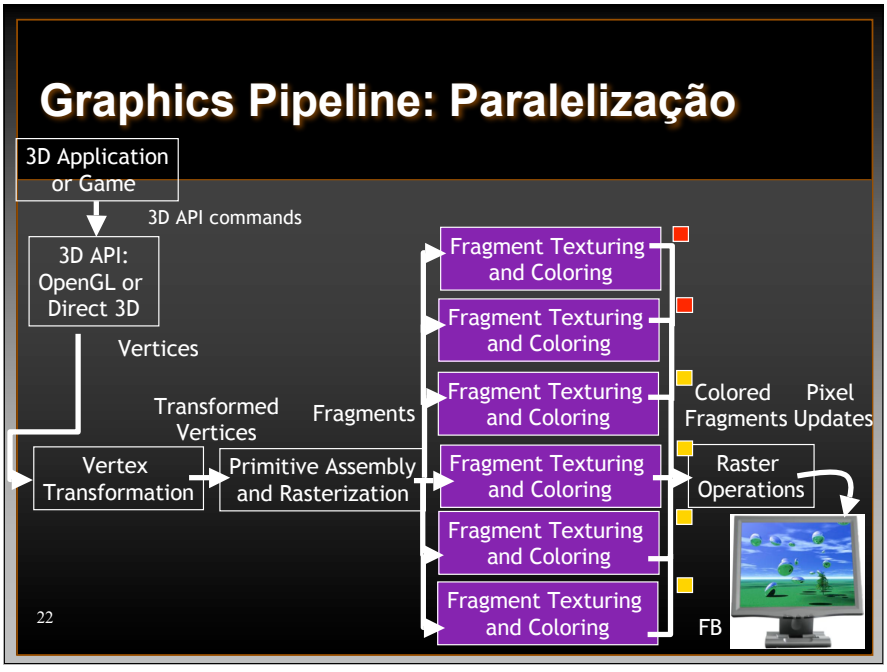
Graphics Pipeline: Paralelização
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Primitive Assembly and Rasterization
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Fragment Texturing and Coloring
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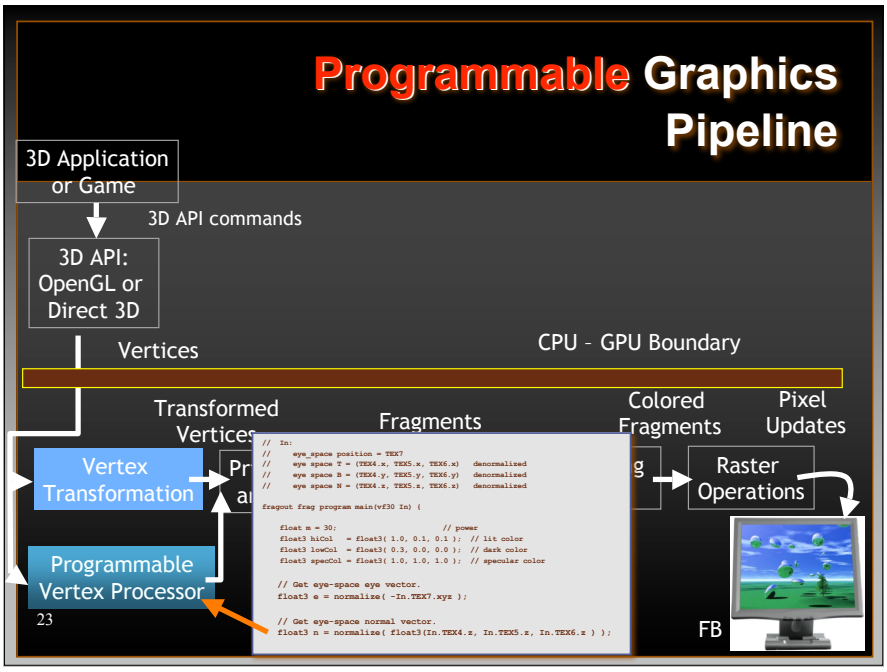
Fragment Texturing and Coloring
Fragment Texturing and Coloring
Fragment Texturing and Coloring
Colored Fragments
Pixel Updates
Raster Operations
FB
22


Programmable Graphics Pipeline
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
Vertices
CPU - GPU Boundary
Transformed Vertices
Fragments
Colored Fragments
Pixel Updates
Vertex Transformation
Programmable Vertex Processor
Raster Operations
FB
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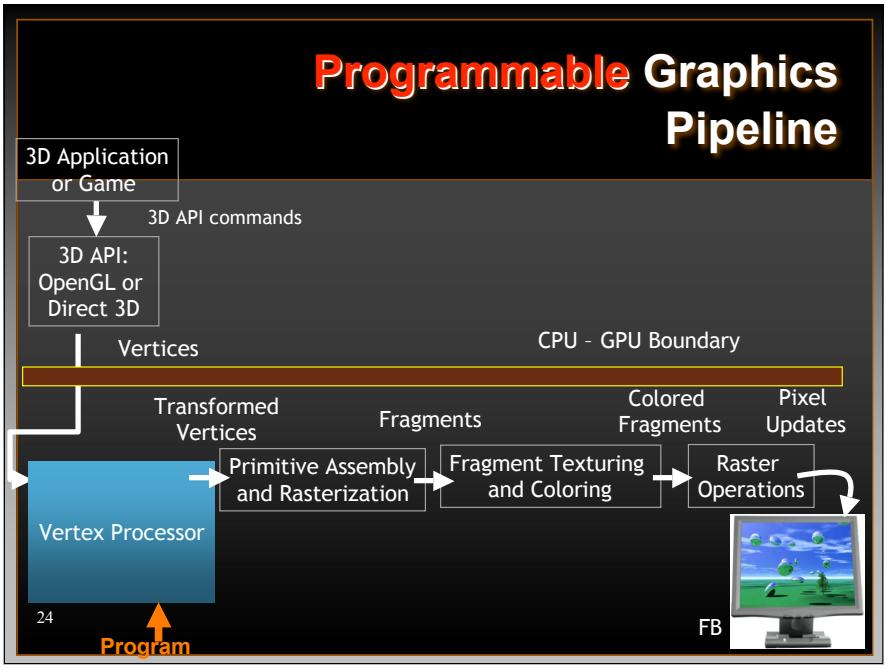
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Primitive Assembly and Rasterization
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Raster Operations
Vertex Processor
Program
FB
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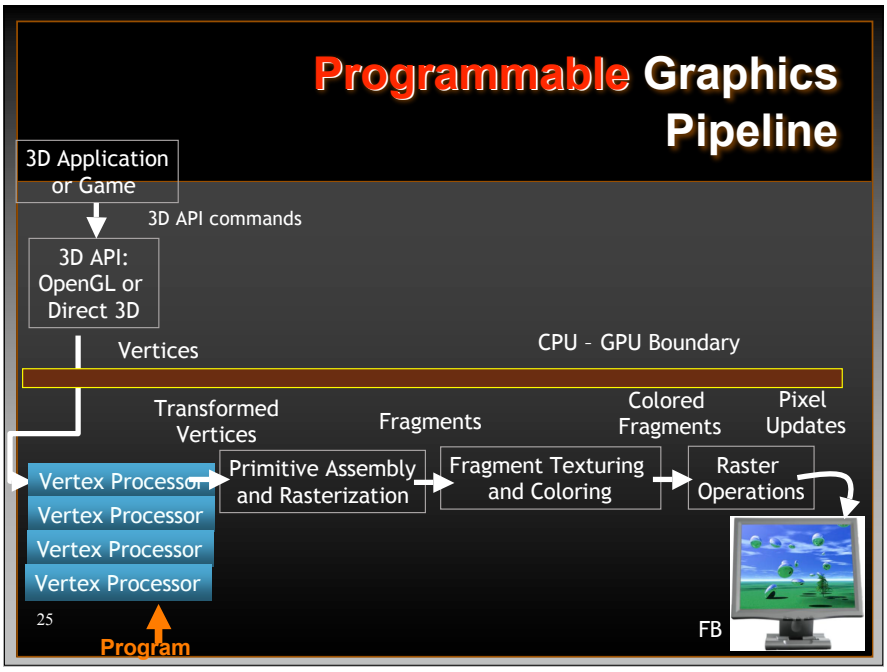
Programmable Graphics Pipeline
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Pixel Updates
Vertex Processor
Vertex Processor
Vertex Processor
Vertex Processor
Primitive Assembly and Rasterization
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Raster Operations
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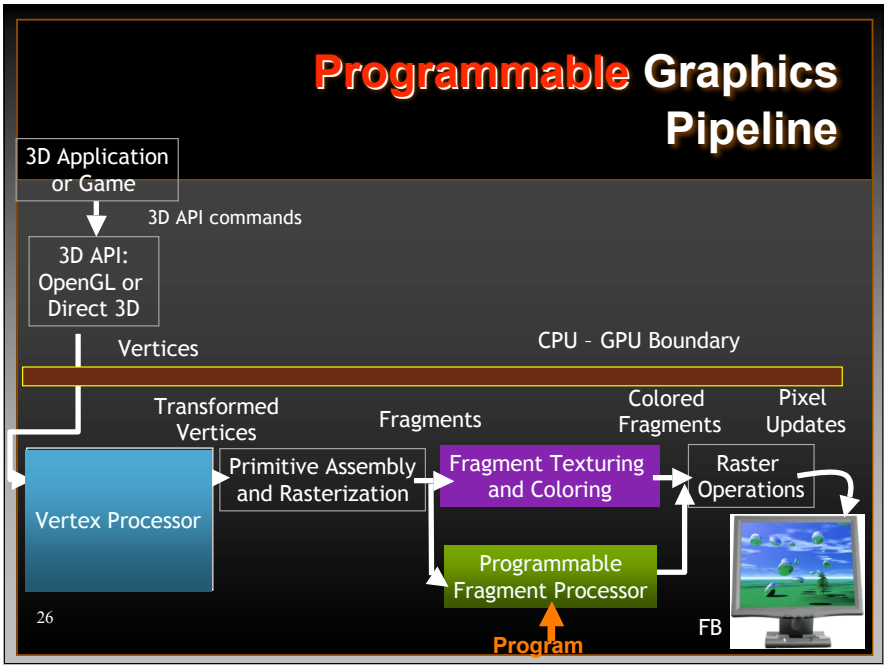
Program


Programmable Graphics Pipeline
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Vertices
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Fragments
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Pixel Updates
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Primitive Assembly and Rasterization
Fragment Texturing and Coloring
Raster Operations
Programmable Fragment Processor
FB
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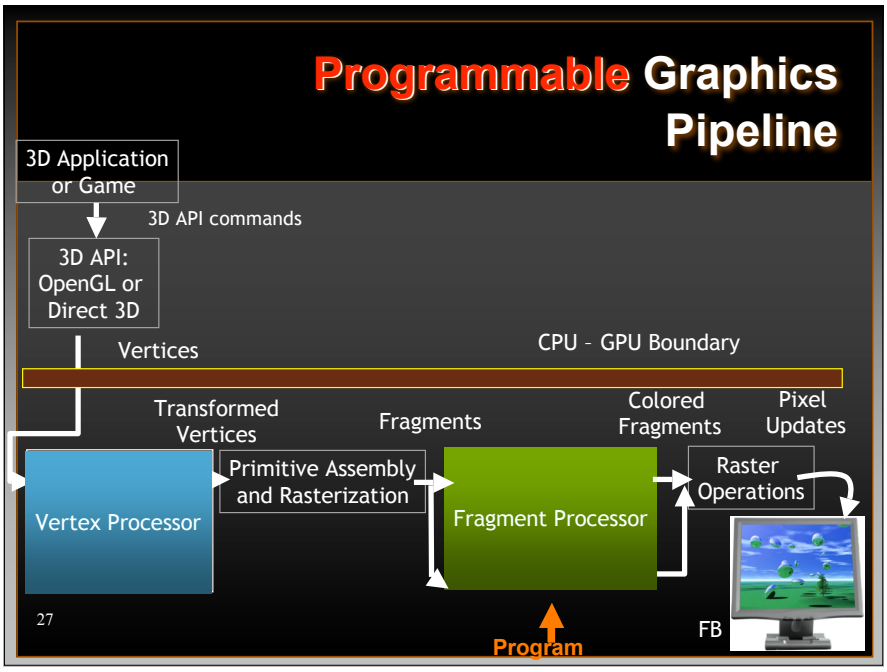
Program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Pixel Updates
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Raster Operations
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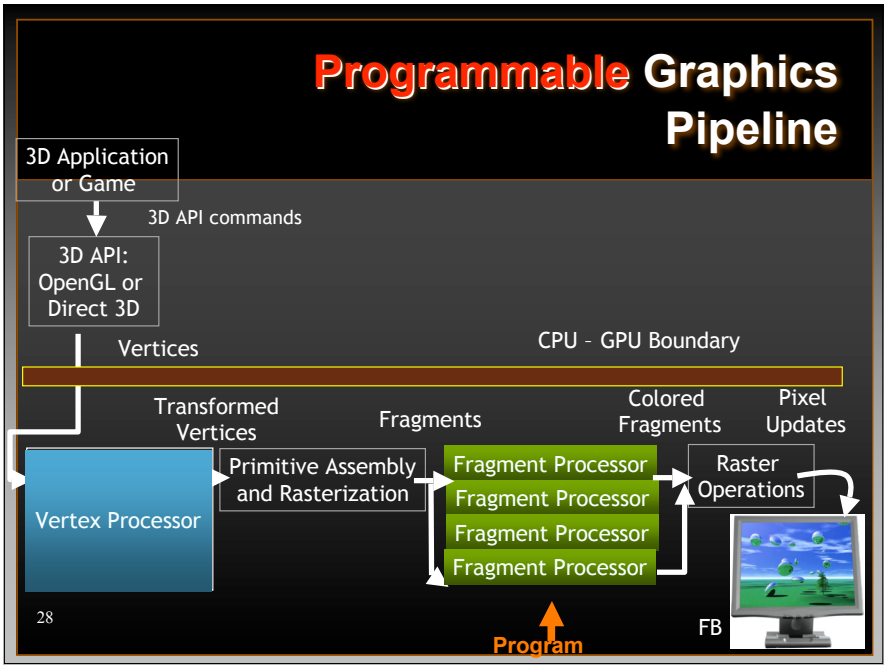
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Fragment Processor
Fragment Processor
Fragment Processor
Raster Operations
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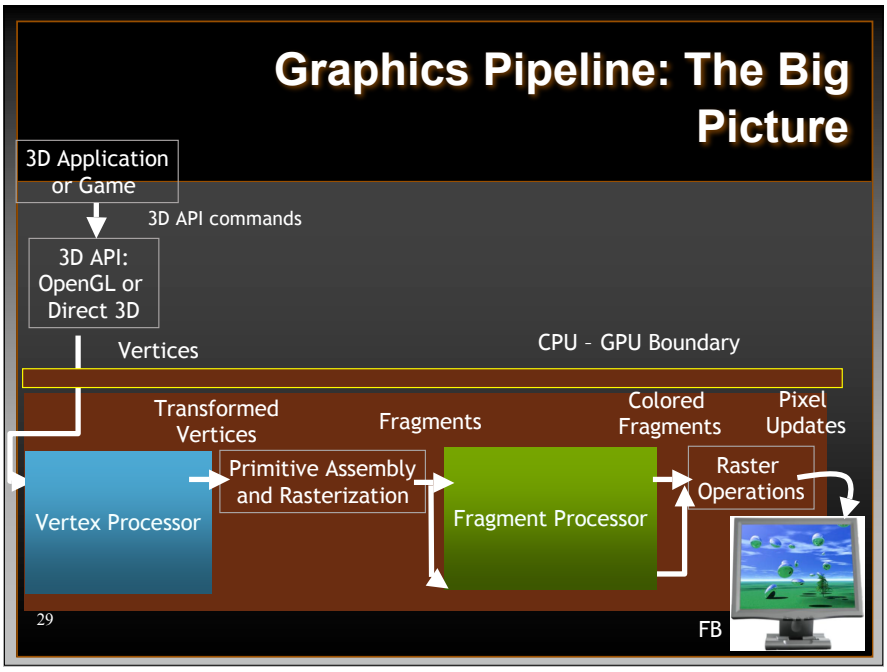
Graphics Pipeline: The Big Picture
3D Application or Game
3D API commands
3D API: OpenGL or Direct 3D
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CPU – GPU Boundary
Transformed Vertices
Fragments
Colored Fragments
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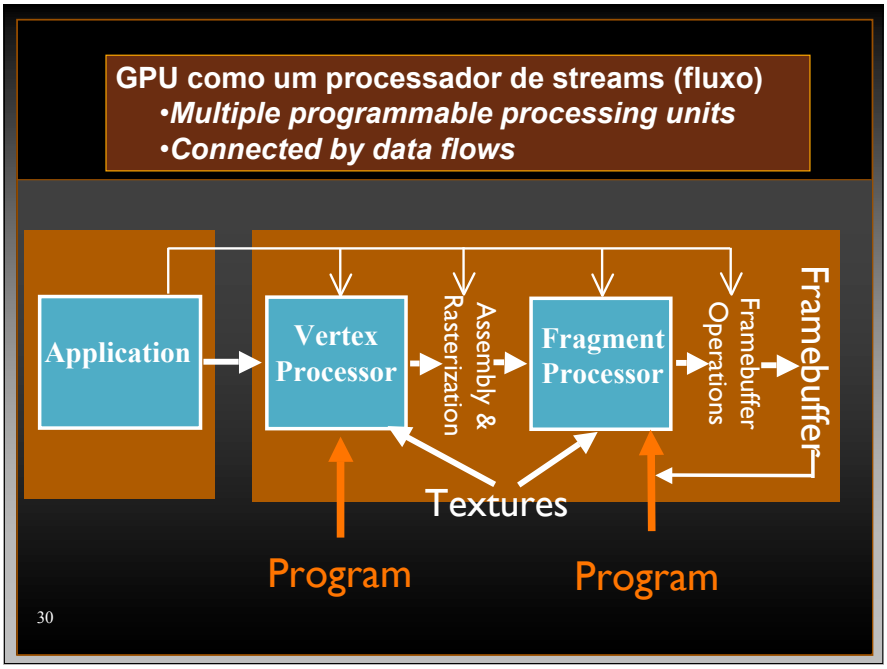
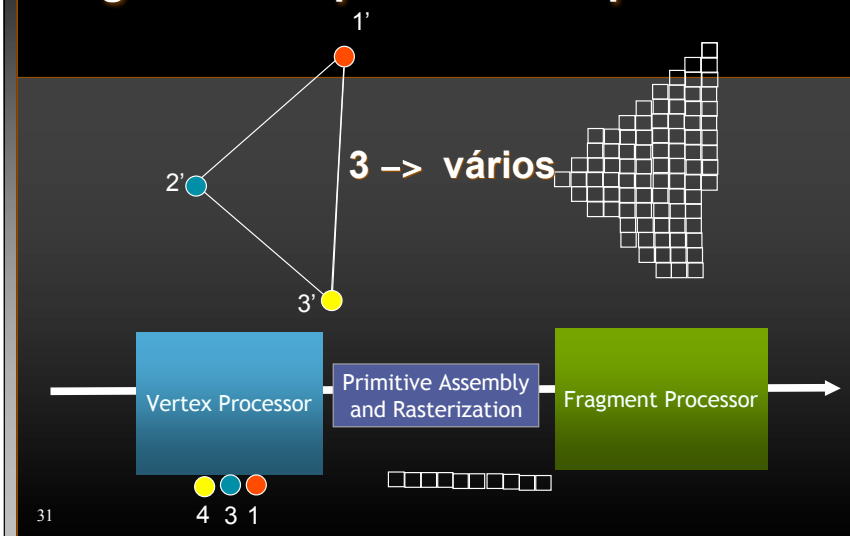

GPU como um processador de streams (fluxo)
•Multiple programmable processing units
•Connected by data flows
Application
Vertex Processor
Assembly & Rasterization
Fragment Processor
Framebuffer Operations
Framebuffer
Textures
Program
Program
30

Gargalos: Computation Frequencies



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Processador de Vértices

- **Totalmente programável (SIMD / MIMD)**
- **Processa 4-vectors (RGBA / XYZW)**
- **Não consegue ler informações de outros vértices**
  - No edge, face, nor neighboring vertex info
- **Não cria nem deleta vértices**
  - 1 vertex in and 1 vertex out
- **Programas podem ser carregados dinamicamente**
- **Vertex Texture Fetch**
  - Consegue acessar texturas

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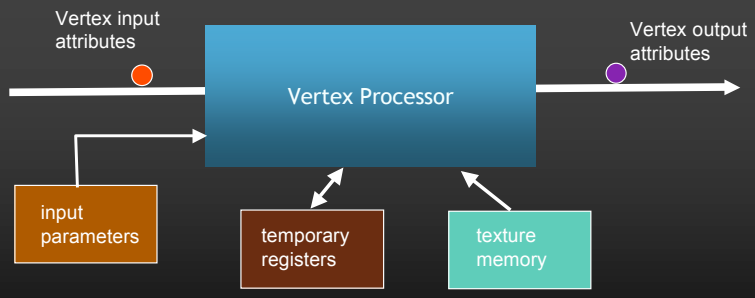
Processador de Vértices



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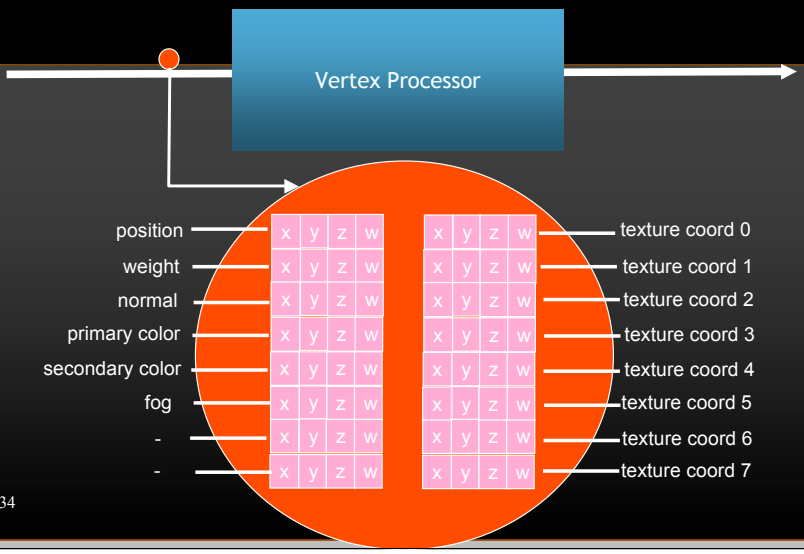
Atributos de Entrada dos Vértices



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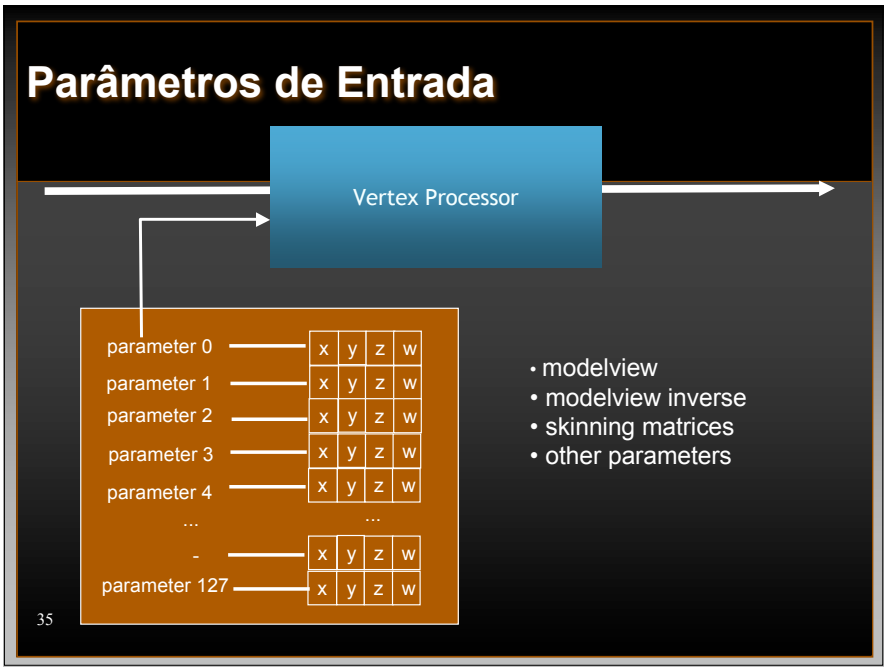
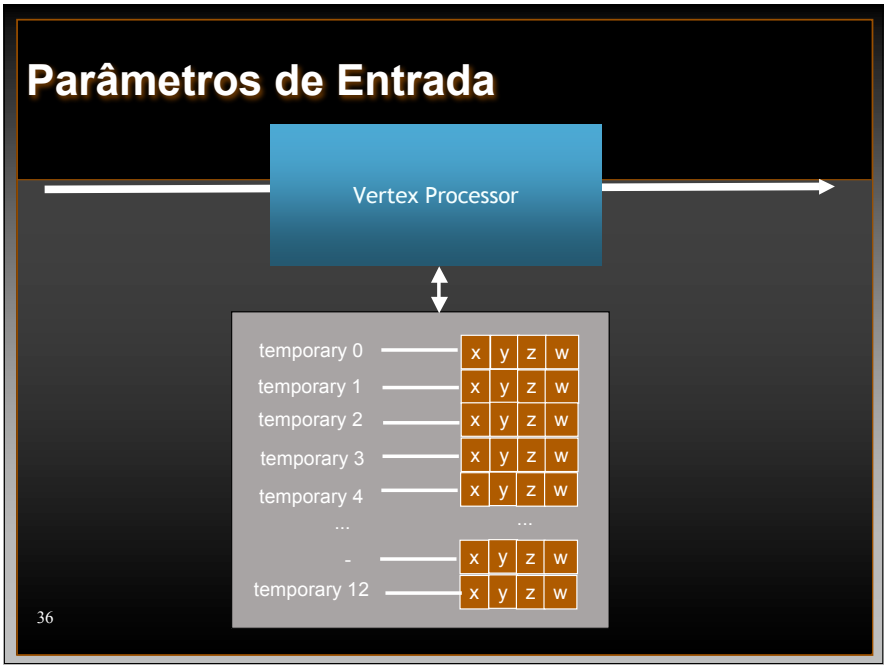

Parâmetros de Entrada
Vertex Processor
parameter 0
parameter 1
parameter 2
parameter 3
parameter 4
...
-
parameter 127
x y z w
• modelview
• modelview inverse
• skinning matrices
• other parameters
35


Parâmetros de Entrada
Vertex Processor
temporary 0
temporary 1
temporary 2
temporary 3
temporary 4
...
-
temporary 12
x y z w
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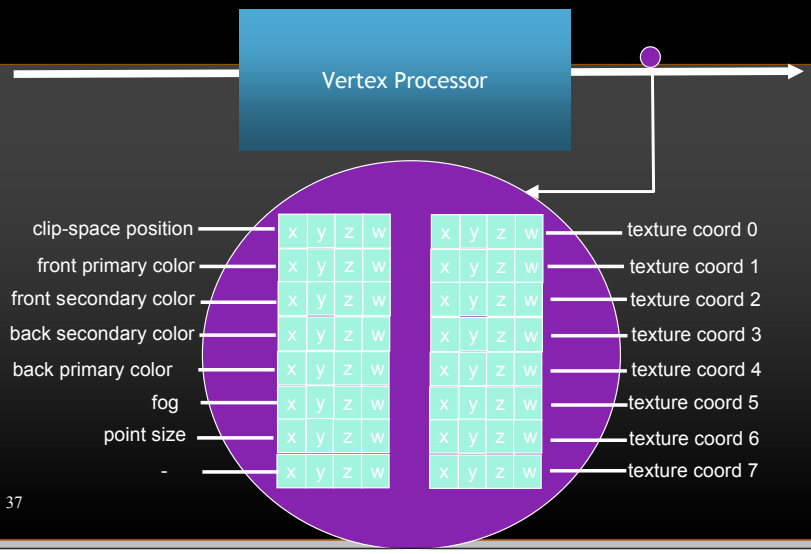
Atributos de Saída dos Vértices



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Processador de Fragmentos

- **Totalmente programável (SIMD)**
- **Processa vectors (4 valores)(RGBA / XYZW)**
- **Acesso a Texturas**
- **Render to Texture**
  - Fragmentos transformados em pixels são escritos numa textura e não enviados ao FB
- **Tipicamente mais útil do que o VP**
  - Mais pipelines de fragmentos do que de vértices

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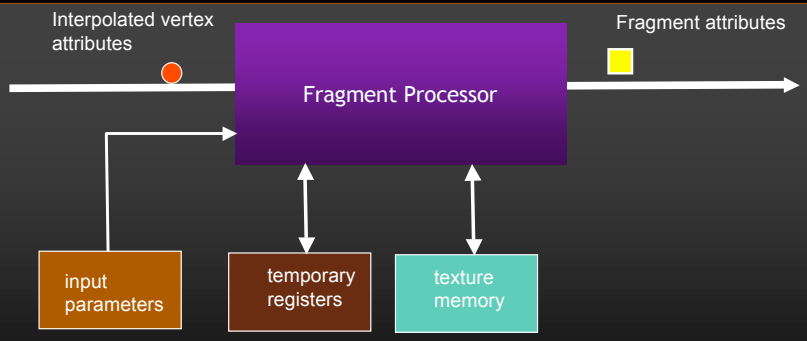
Processador de Fragmentos



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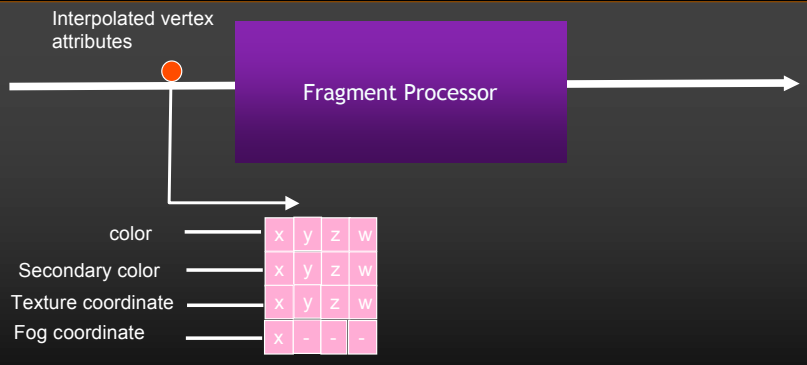
Atributos de Entrada



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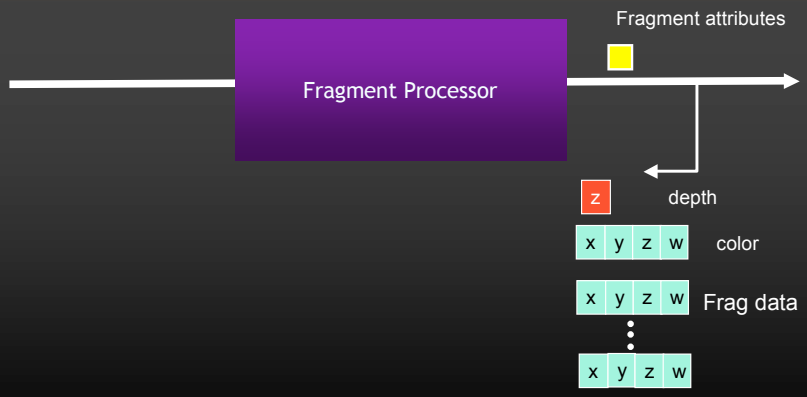
Atributos de Saída



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Tipos de Dados

- **Scalars: float/integer/boolean**
  - Precisão de 32 ou 16 bits
  - ATI suporta 24 bits
  - GLSL tem inteiros de 16 bits
- **Vector**
  - 3 ou 4 componentes
- **Arrays (de tamanho fixo)**
- **No bit operations**
- **Matrix data types**
- **Texture data type**

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Data Binding

Modos:

- uniform: o parâmetro é fixo dentro de uma chamda glBegin()-glEnd()
- varying: dados interpolados enviados ao programa de fragmento (ex. cor pixel, coordenadas de textura)
- attribute: dados per-vertex enviados à GPU pela CPU (coordenadas de vértices, coordenadas de texturas, normais, etc).

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Data Binding

- Direção:
- in: dados enviados para dentro do programa (ex. vertex coordinates)
- out: dados enviados para fora do the programa (ex. depth)
- inout: ambos acima (ex. cor)

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Operações e Fluxo de Controle

- Aritmética usual e operações algébricas especiais (trigonometry, interpolation, discrete derivatives, etc)
- No integer mod...
- for-loops, while-do loops, if-then-else statements.
- `discard` permite desabilitar um fragmento e encerrar o processamento
- Chamadas recursivas não estão suportadas
- Sempre uma função “main” default que começa o programa

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