The Cg Runtime

Cyril Zeller

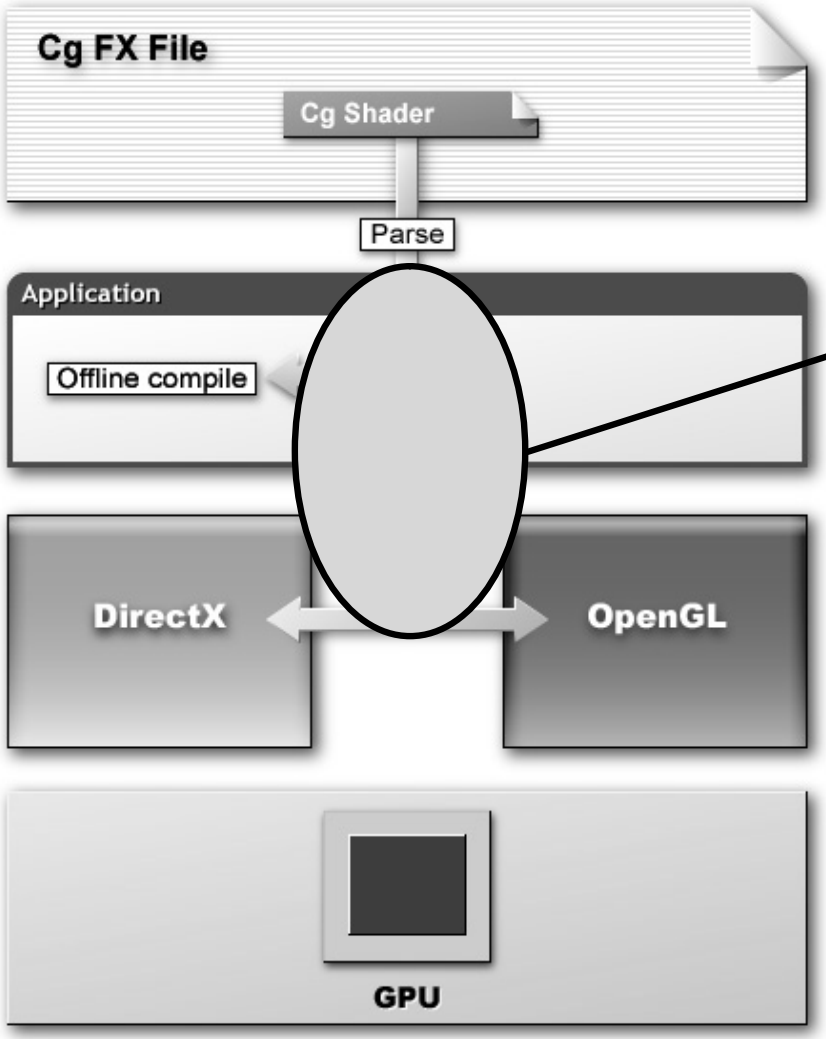
Cg Pipeline

Graphics programs are written in Cg ...

... and compiled to ...

... low-level assembly code ...

... that runs on any GPU compatible with DirectX or OpenGL



Cg Runtime API

Compiling Offline

At Development Time

Cg program source code

```
//
// Diffuse lighting
//
float d = dot(normalize(frag.N),
normalize(frag.L));
if (d < 0)
  d = 0;
c = d*tex2D(t, frag.uv)*diffuse;
…
```

Cg Compiler

Shader program assembly code

```
…
DP3 r0.x, f[TEX0], f[TEX0];
RSQ r0.x, r0.x;
MUL r0, r0.x, f[TEX0];
DP3 r1.x, f[TEX1], f[TEX1];
RSQ r1.x, r1.x;
MUL r1, r1.x, f[TEX1];
DP3 r0, r0, r1;
MAX r0.x, r0.x, 1.0;
MUL r0, r0.x, DIFFUSE;
TEX r1, f[TEX1], 0, 2D;
MUL r0, r0, r1;
…
```

Shader Compiler (nvasm.exe, psa.exe)

Shader program binary code

```
012b40   00 00 00 00 00 00 00 00
012b50   42 CD 09 84 51 3F 84 3C
012b60   93 AB D9 B1 87 87 70 B2
012b70   5C A5 D1 1C 58 65 58 F4
012b80   1F 27 1F 22 22 1F 1F 22
012b90   12 22 22 12 22 22 22 22
012ba0   1F 2F 2F 2F 2F 2F 23 FF
012bb0   37 37 37 37 37 37 2C 2C
012bc0   30 BE 47 04 4A BE A8 E6
012bd0   50 78 92 DD 90 B9 72 CE
012be0   03 69 8D EE 46 73 85 F9
```

At Runtime

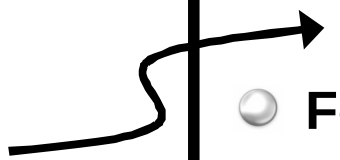
- **At initialization:**
  - **Load assembly or binary program**
- **For every frame:**
  - **Load program parameters to hardware registers**
  - **Set rendering state**
  - **Load geometry**
  - **Render**

Compiling at Runtime

At Development Time

Cg program source code

```
//
// Diffuse lighting
//
float d = dot(normalize(frag.N),
normalize(frag.L));
if (d < 0)
  d = 0;
c = d*tex2D(t, frag.uv)*diffuse;
…
```



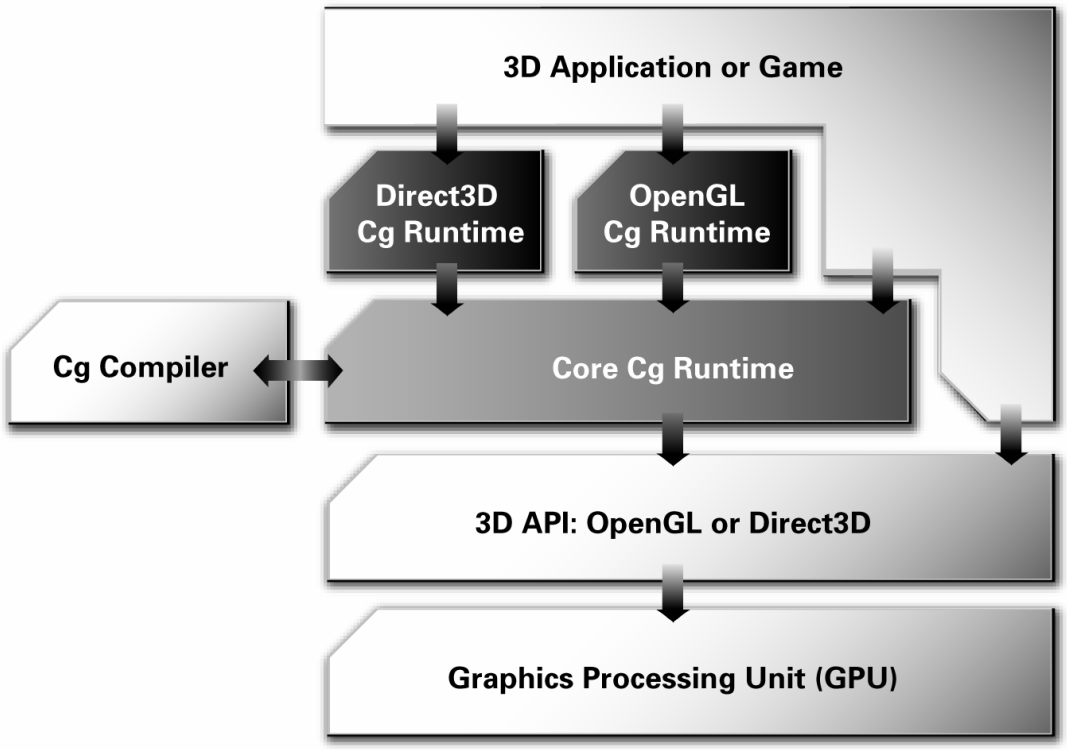
At Runtime

- **At initialization:**
  - **Compile and load Cg program**
- **For every frame:**
  - **Load program parameters with the Cg Runtime API**
  - **Set rendering state**
  - **Load geometry**
  - **Render**

Pros and Cons of Runtime Compilation

- **Pros:**
  - **Future compatibility: The application does not need to change to benefit from future compilers (future optimizations, future hardware)**
  - **Easy parameter management**
- **Cons:**
  - **Loading takes more time because of compilation**
  - **Cannot tweak the result of the compilation**

Cg Runtime Architecture



- Core Cg Runtime: cgCreateProgram
- Direct3D Cg Runtime: cgD3D9LoadProgram
- OpenGL Cg Runtime: cgGLLoadProgram

Core Cg Runtime

- Does *not* make any 3D API call
- Allows you to:
  - Create a context: `cgCreateContext()`
  - Compile a program for a given profile (`vs_2_0`, `vs_2_x`, `ps_2_0`, `ps_2_x`, arbvp1, arbvp1, `vs_1_1`, `ps_1_1`, fp20, etc...): `cgCreateProgram()`, `cgGetProgramString()`, etc...
  - Manage program parameters:
    - Iterate through the parameters: `cgGetFirstParameter()`, `cgGetNextParameter()`, etc...
    - Get parameter information: type, semantic, register, ...
  - Handle errors: `cgGetError()`, `cgSetErrorCallback()`, etc...

Direct3D Cg Runtime: Minimal Interface

- Does *not* make any Direct3D call
- Allows you to translate the information obtained through the Core Runtime to Direct3D data structures, so that you can:
  - Create a Direct3D vertex declaration from the Cg program: `cgD3D9GetVertexDeclaration()`
  - Validate a Direct3D vertex declaration against the Cg program: `cgD3D9ValidateVertexDeclaration()`

  and create a Direct3D vertex or pixel shader from the Cg program

Direct3D Cg Runtime: Expanded Interface

- Makes the necessary Direct3D calls for you
- Allows you to:
  - Pass the Direct3D device: `cgD3D9SetDevice()`
  - Load a program into Direct3D: `cgD3D9LoadProgram()`
  - Tell Direct3D to render with it: `cgD3D9BindProgram()`
  - Set parameter values: `cgD3D9SetUniform()`, `cgD3D9SetUniformArray()`, `cgD3D9SetTexture()`, etc...
  - Output debug information by using the Cg Runtime debug DLL

OpenGL Cg Runtime

- Makes the necessary OpenGL calls for you
- Allows you to:
  - Load a program into OpenGL: `cgGLLoadProgram()`
  - Enable a profile: `cgGLEnableProfile()`
  - Tell OpenGL to render with it: `cgGLBindProgram()`
  - Set parameter values: `cgGLSetParameter{1234}{fd}{v}()`, `cgGLSetParameterArray{1234}{fd}()`, `cgGLSetTextureParameter()`, etc...

Learning the Runtime

- **The documentation is in:**
  - **Windows: C:\Program Files\NVIDIA Corporation\Cg\docs**
  - **Linux: /usr/share/doc/Cg**

  It includes:
  - **A Using the Cg Runtime Library chapter from the Cg User's Manual**
  - **Manual pages for every function**

- **Source code examples are in:**
  - **Windows: C:\Program Files\NVIDIA Corporation\Cg\examples**
  - **Linux: /usr/local/Cg/examples**

  They include self-contained Direct3D and OpenGL examples

Questions, comments, feedback?

- Cyril Zeller, czeller@nvidia.com
- For Cg support
  - Go to developer.nvidia.com/Cg
  - Go to www.cgshaders.org
  - Email cgsupport@nvidia.com