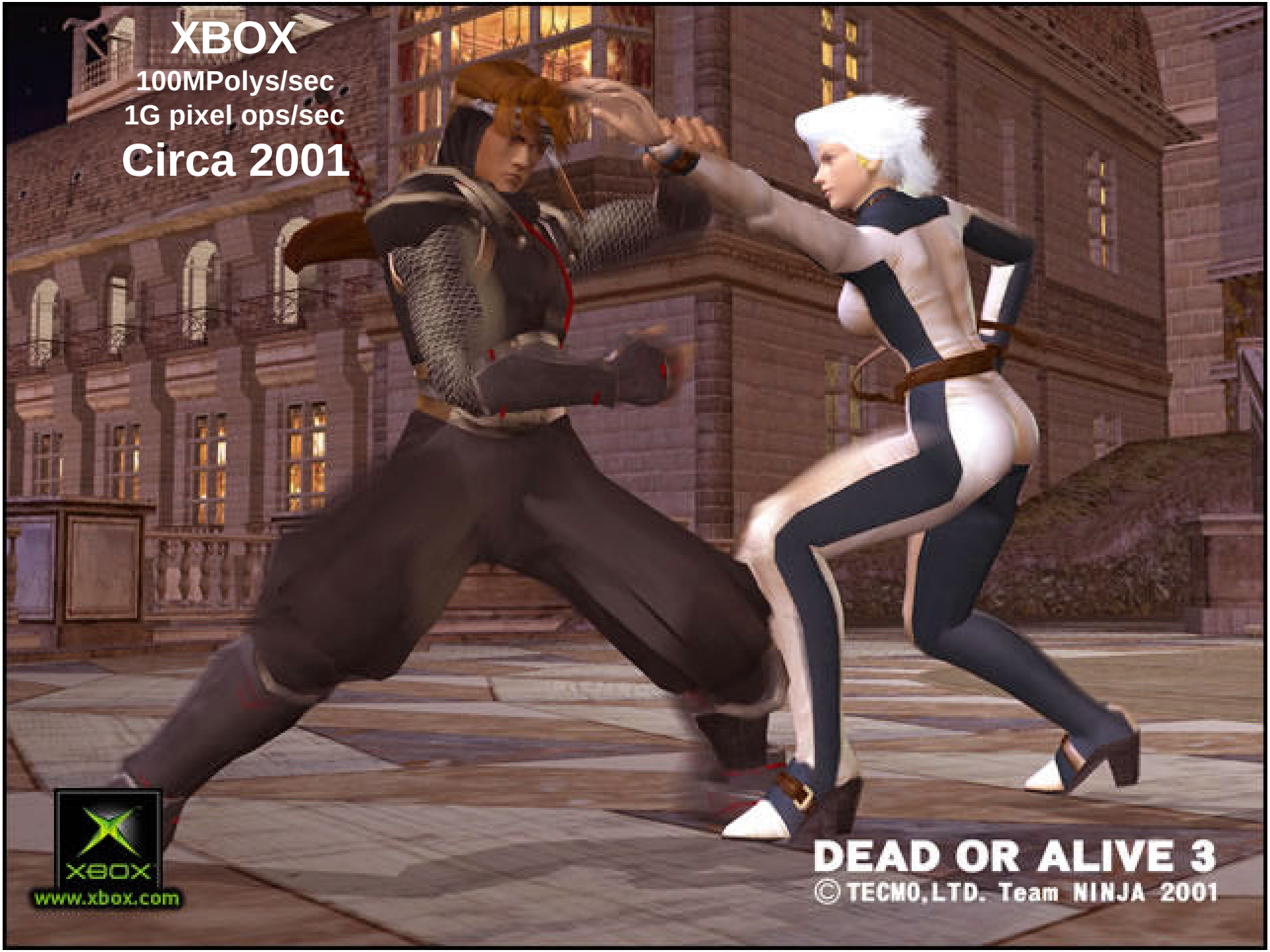
NVIDIA®

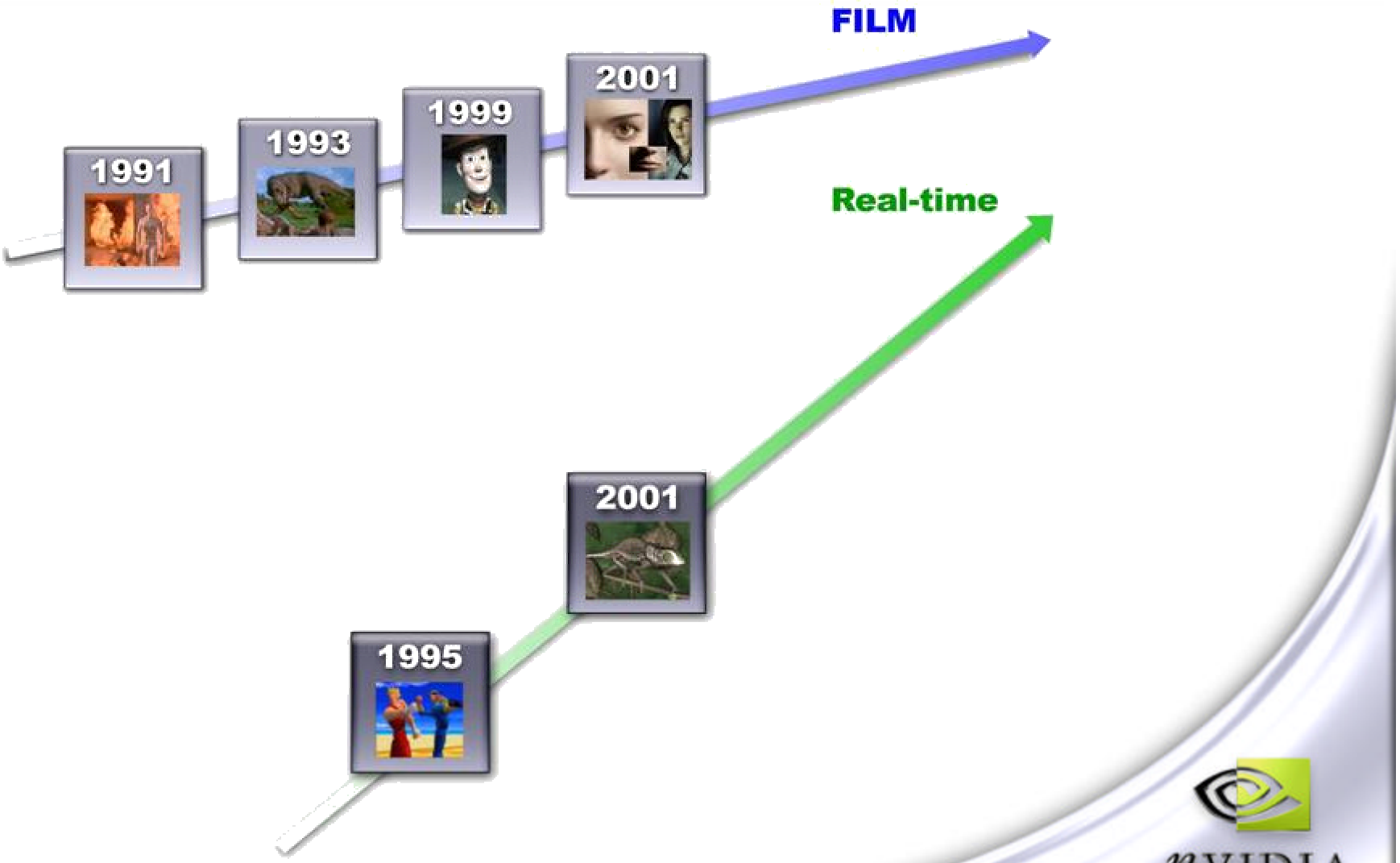
CineFX Architecture

Siggraph 2002


NV1
SEGA Virtua Fighter
50K polygons/sec
1M pixel ops/sec
Circa 1995


XBOX
100MPolys/sec
1G pixel ops/sec
Circa 2001
XBOX
www.xbox.com
DEAD OR ALIVE 3
© TECMO, LTD. Team NINJA 2001

Convergence of Film and Real-time Rendering



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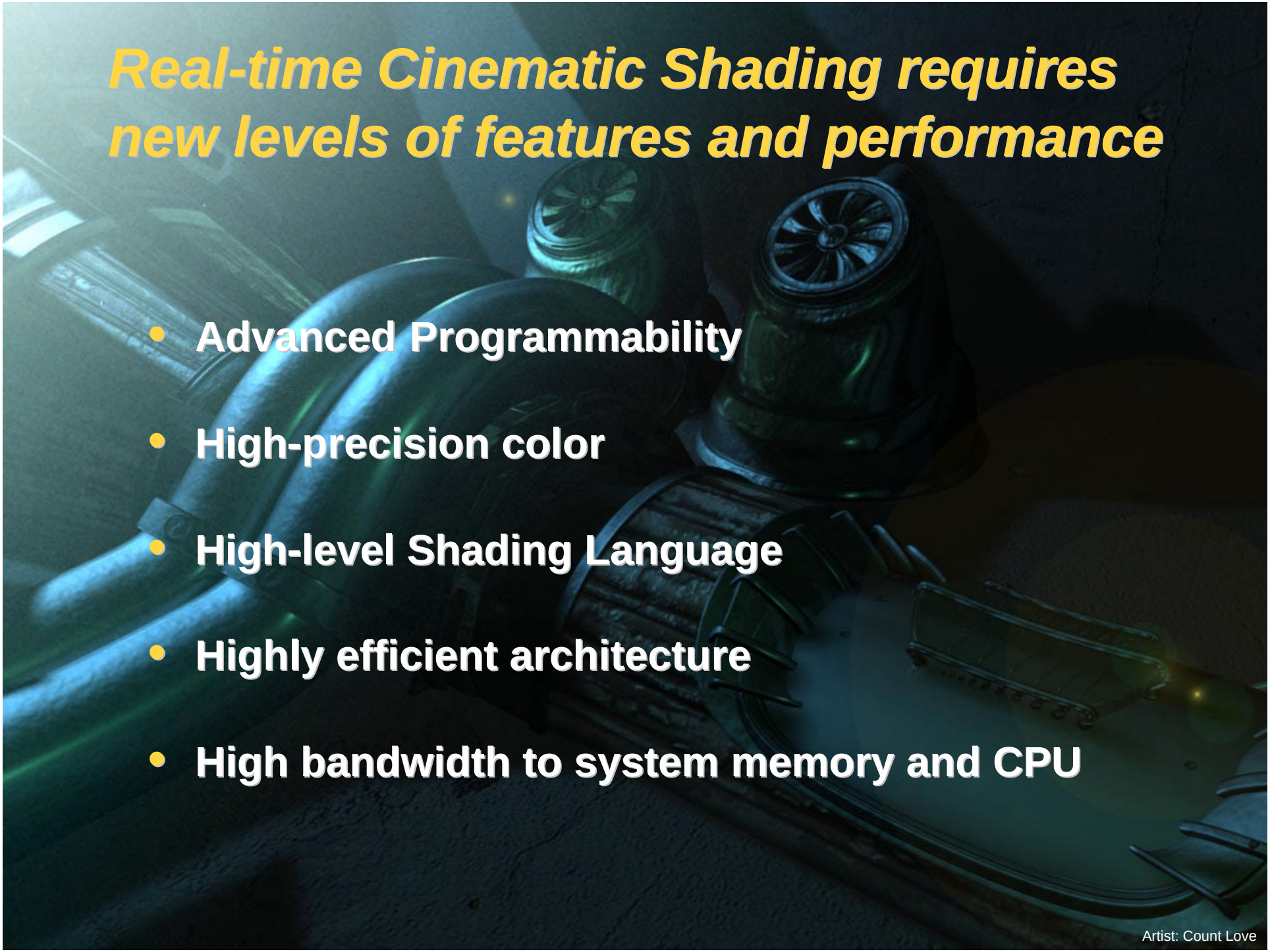
Cinematic Shading

Final Fantasy
The Spirits Within
Square


Real-time Cinematic Shading requires new levels of features and performance
Advanced Programmability
High-precision color
High-level Shading Language
Highly efficient architecture
High bandwidth to system memory and CPU
Artist: Count Love

Introducing the CineFX Architecture

- Generalized Vertex Processing
- Generalized Pixel Processing
- 128-bit Floating Point Precision
- Highly advanced rendering architecture
- Dramatically improved performance

CineFX

Generalized Vertex Processing

- Up to 65536 vertex instructions
- 256 constants
- Loops & Branching
  - Forward & backwards
  - Data Dependent
- Call & Return - Subroutines
- Per component condition codes & write masks
  - Faster than branching for short basic blocks

	DX8.0	R300	CineFX
Vertex Shaders	1.1	2.0	2.0+
Max Instructions	128	1024	65536
Max Static Instructions	128	256	256
Max. Constants	96	256	256
Temporary Registers	12	12	16
Max Loops	0	4	256
Conditional Write Masks	-	-	✓
Call & Return	-	-	✓
Static Flow Control	-	✓	✓
Dynamic Flow Control	-	-	✓

CineFX

Vertex Processing Instruction Set

- **Add & multiply instructions**
  ADD, DP3, DP4, DPH, MAD, MOV, SUB
- **Math functions**
  ABS, COS, EX2, EXP, FLR, FRC, LG2, LOG, RCP, RSQ, SIN
- **Set on instructions**
  SEQ, SFL, SGR, SGT, SLE, SLT, SNE, STR
- **Branching instructions**
  BRA, CAL, RET
- **Address register instructions**
  ARL, ARA
- **Graphics-oriented instructions**
  DST, LIT, RCC, SSG
- **Minimum / maximum instructions**
  MAX, MIN

CineFX

Vertex Processing Example – Matrix Palette Skinning

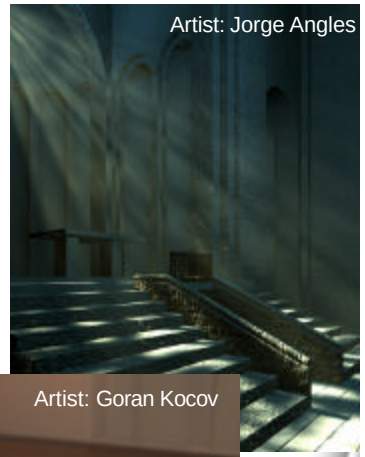
- DX8 / NV2x / R200 / RV250
  - 4 shaders
    - 1 bone
    - 2 bone
    - 3 bone
    - 4 bone
  - Segment Model into those polys depending on 1,2,3,4 bones
  - Draw separately
- DX9 / R300
  - 1 shader (1-4 bones)
  - Branching is *per-object*
  - Still have to segment model into 1-4 bone groups
  - Draw separately
- CineFX
  - 1 shader
  - Branching is *per-vertex*
  - No need to segment model
  - Loop is done conditionally on a per-vertex level

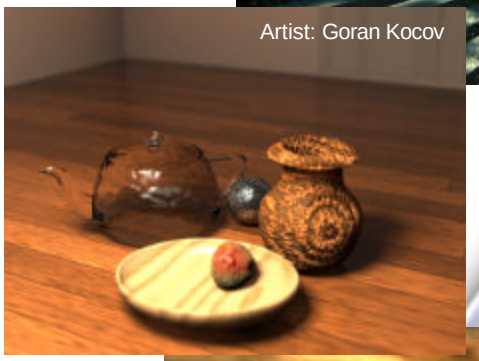
CineFX

Generalized Pixel Shading

- **All the features of GeForce4 vertex programs – for pixels!**
- **Full instruction set for pixels**
- **Up to 1024 shader instructions**
- **Up to 16 textures per pixel**
- **Instruction predicates for conditional execution**
- **Per component swizzling**
- **Per component write masks**
- **Arbitrary Texture Filters**

	DX8.0	R300	NV30
Pixel Shaders	1.1	2.0	2.0+
Texture Maps	4	16	16
Max. Texture Instructions	4	32	1024
Max. Color Instructions	8	64	1024
Max Temp Storage	-	12	64
Instruction Predicates	-	-	✓
Unlimited Dependent Textures	-	-	✓
Swizzling	-	-	✓
Advanced Instructions	-	-	✓
Conditional Write Masks	-	-	✓





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Pixel Shading Instruction Set

- **Add & multiply instructions**
  ADD, DP3, DP4, LRP, MAD, MOV, SUB, X2D
- **Texturing instructions**
  TEX, TXD, TXP
- **Partial derivative instructions**
  DDX, DDY
- **Math functions**
  COS, EX2, FLR, FRC, LG2, POW, RCP, RSQ, SIN
- **Set on instructions**
  SEQ, SFL, SGR, SGT, SLE, SLT, SNE, STR
- **Graphics-oriented instructions**
  DST, LIT, RFL
- **Minimum / maximum instructions**
  MAX, MIN
- **Pack instructions**
  PK2H, PK2US, PK4B, PK4UB, PK4UBG
- **Unpack instructions**
  UP2H, UP2US, UP4B, UP4UB, UP4UBG
- **Kill instruction**
  KIL

CineFX

Unprecedented Precision

- **Record-breaking 128-bit color precision**
  - **Support for 16 or 32-bit floating point components**
  - **64-bit & 128-bit FP color**
  - **64-bit offers improved precision with 2x the performance & ½ the memory of 128-bit**

	DX8	R300	CineFX
Max Precision	32	96	128
32-bit color	✓	✓	✓
64-bit color	-	-	✓
128-bit color	-	-	✓
Format	INT	FP	FP

High Precision Color Details

- 16-bit floating point format
  - The same exact format that Pixar & ILM use for films
  - So-called s10e5 representation
    - 1 bit sign
    - 10 bit mantissa
    - 5 bit exponent, -15 bias
  - Otherwise IEEE 754 floating-point semantics
- More range than signed shorts
- Half the space & bandwidth of a 32-bit floating-point value

- 32-bit Floating Point format: IEEE s23e8

CineFX

High Dynamic Range

Overdark - Underexposed

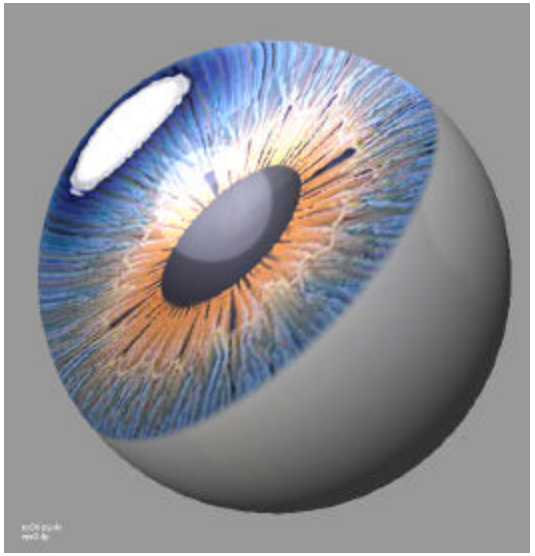
Standard Exposure

Overbright - Overexposed

CineFX

Advanced Graphics Processing

- Render to Vertex Array
  - Displacement Mapping
  - Particle Systems
- Ray Tracing
- Floating Point Cinematic precision compositing



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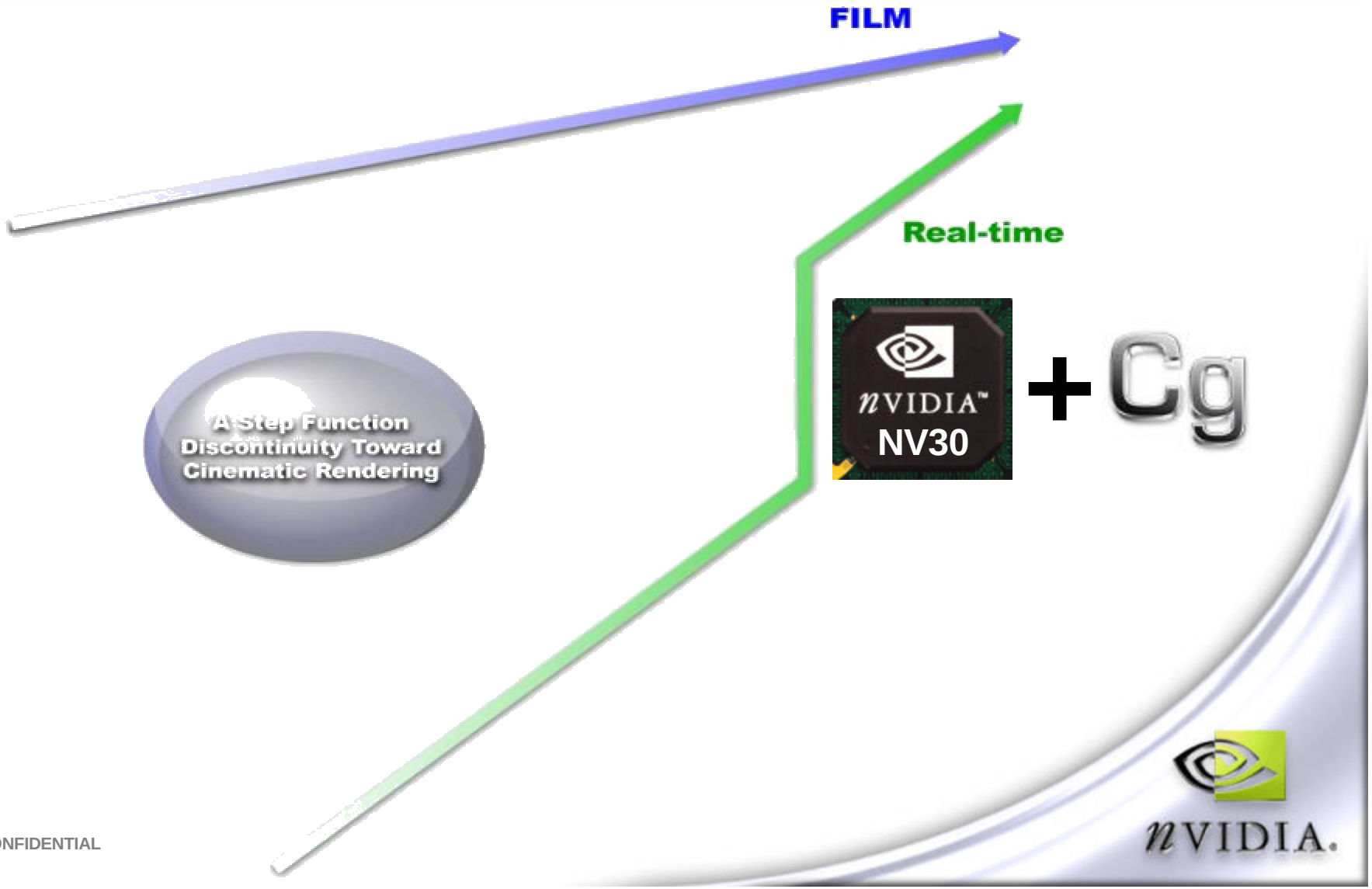
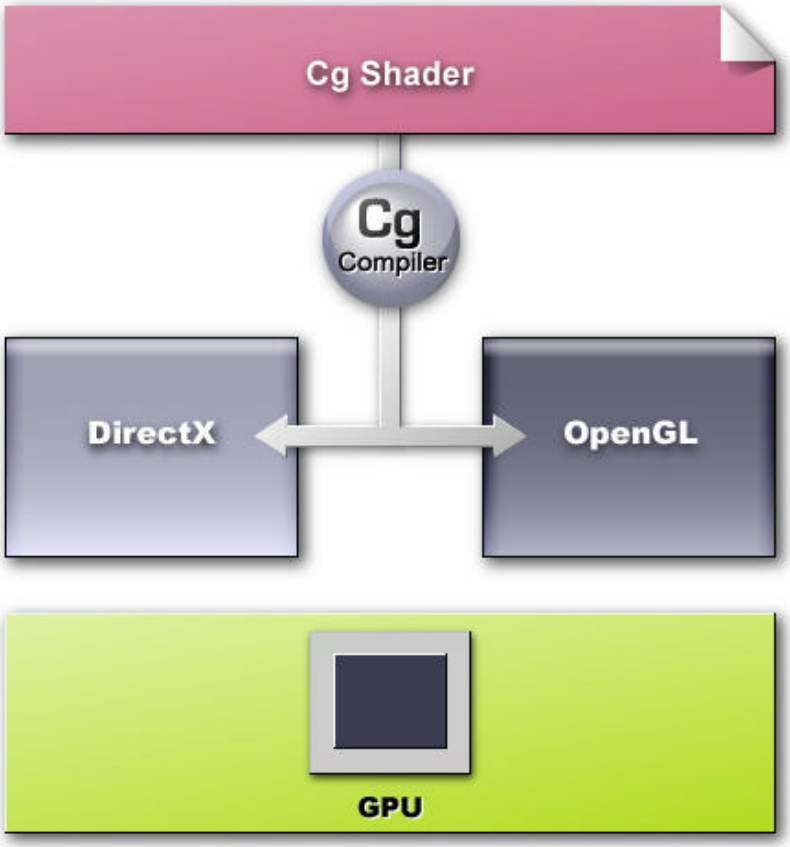


Cg
What developers have been asking for



- C for Graphics – Cg Shader Code written in a High Level Language
- Compiled and optimized
- Into Vertex and Pixel Shader Assembly Code
- 100% compatible with DX9's HLSL

"Cg is a bright light for a black art. Finally cryptic shader tricks can be explored and applied by mere mortals."

Mike Biddlecombe
Programmer - Dungeon Siege
Gas Powered Games

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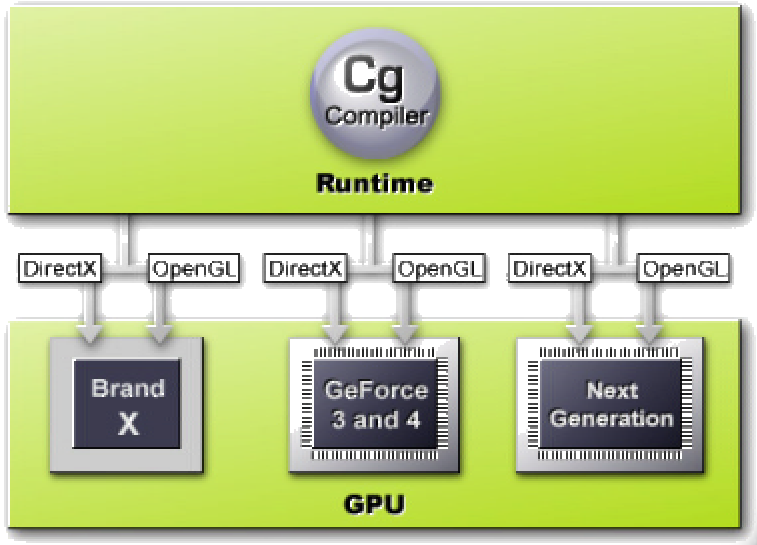
NVIDIA Cg Compiler – Breakthrough Technology

- **Optimized**
  - **Generates the fastest code for NVIDIA GPUs**
- **Flexible**
  - **Outputs DirectX or OpenGL shader programs**
  - **Supports Windows, Linux, Mac OS X, Xbox**
- **Compatible**
  - **Forwards to: DirectX 9, NV30…**
  - **Backwards to: ALL DirectX 8 / OpenGL 1.4 compliant GPUs**



Unified Compiler Architecture

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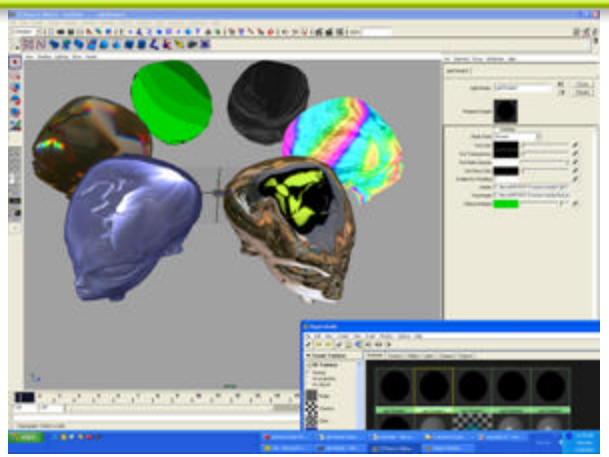
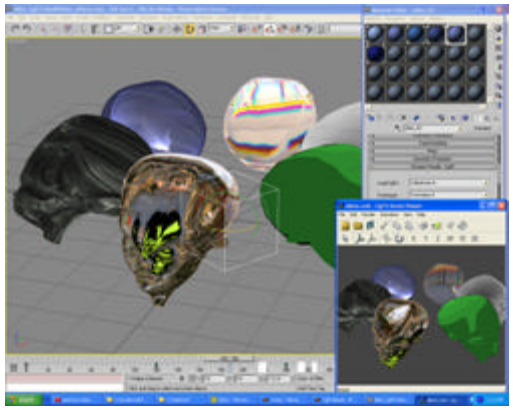
Key DCC Applications integrating Cg

Maya®



3ds max™



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