Radeon X1000
3D Architecture

Architectural Highlights

Focus on Efficiency

- Reduce idle time and latency
- Improve memory access management

Shader Model 3.0 "Done Right"

- High performance dynamic flow control
- Full speed 128-bit rendering

Driving Image Quality Forward

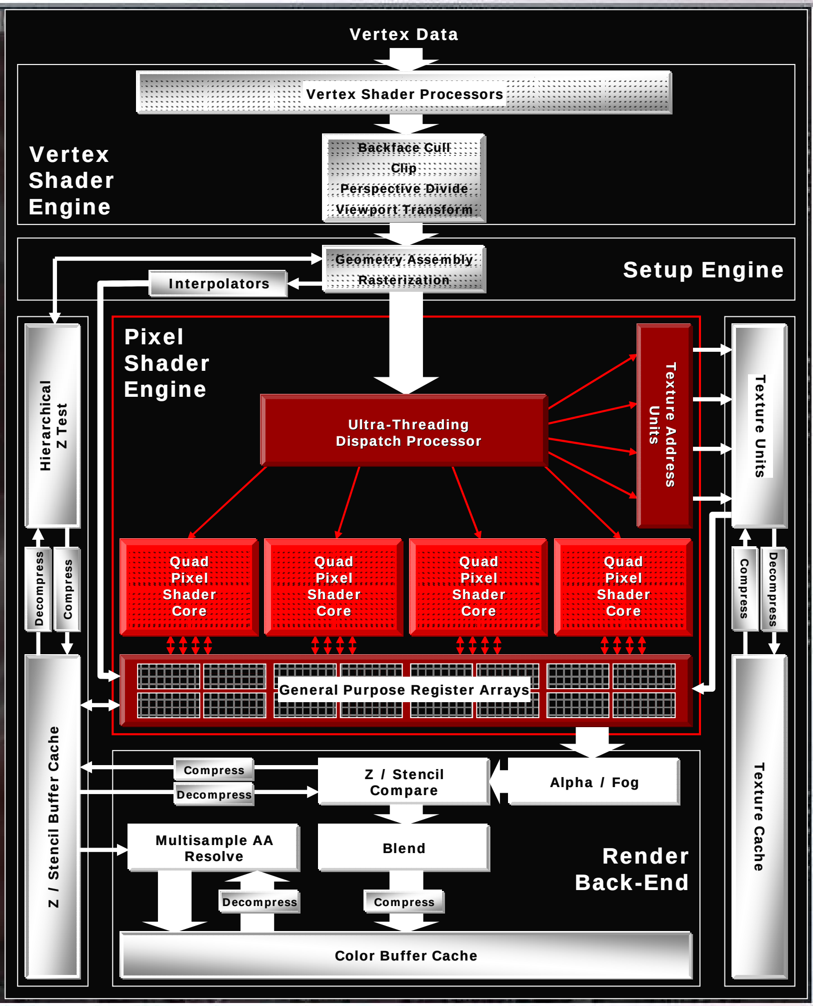
- Advanced high dynamic range rendering
- Adaptive anti-aliasing
- Improved texture filtering quality

Flexibility and Scalability

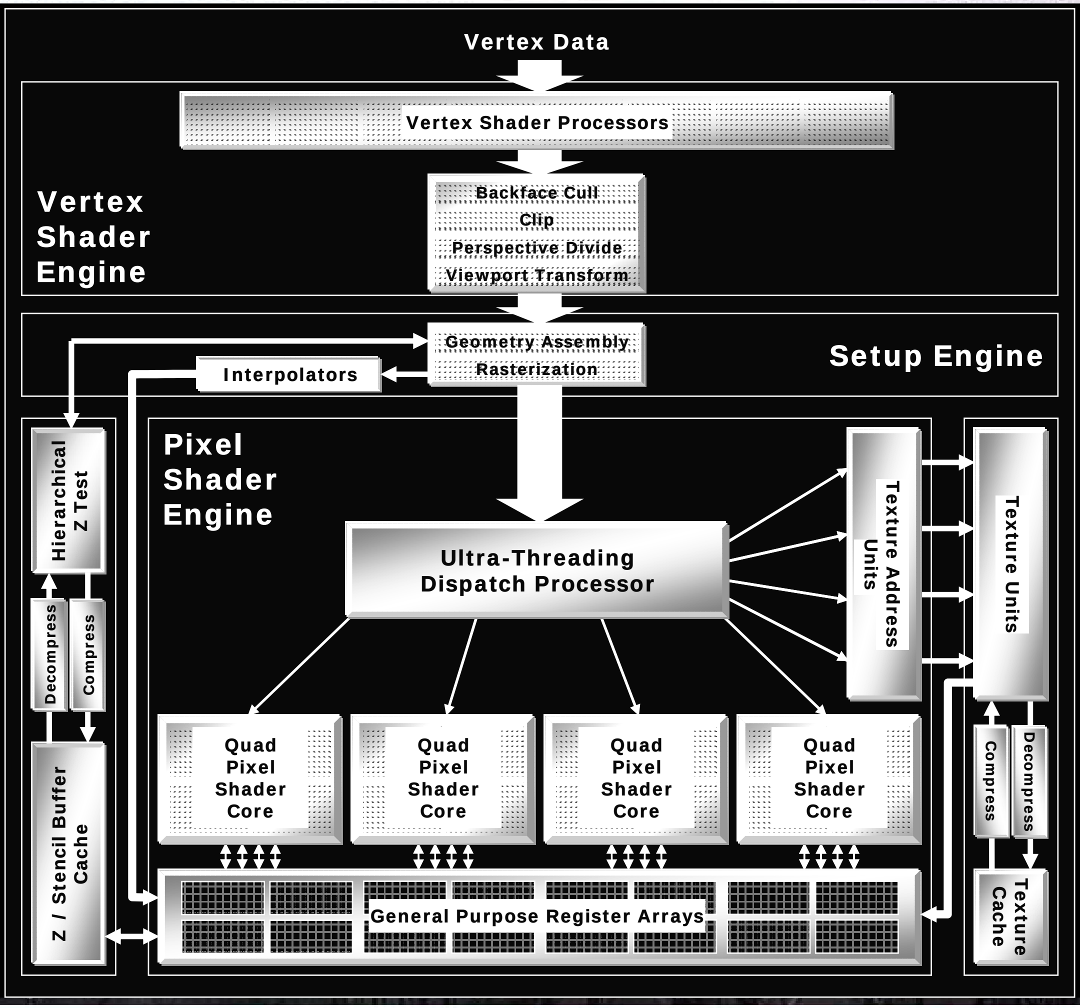
- Decoupling processing units from rigidly defined pipelines

Radeon X1800 3D Architecture

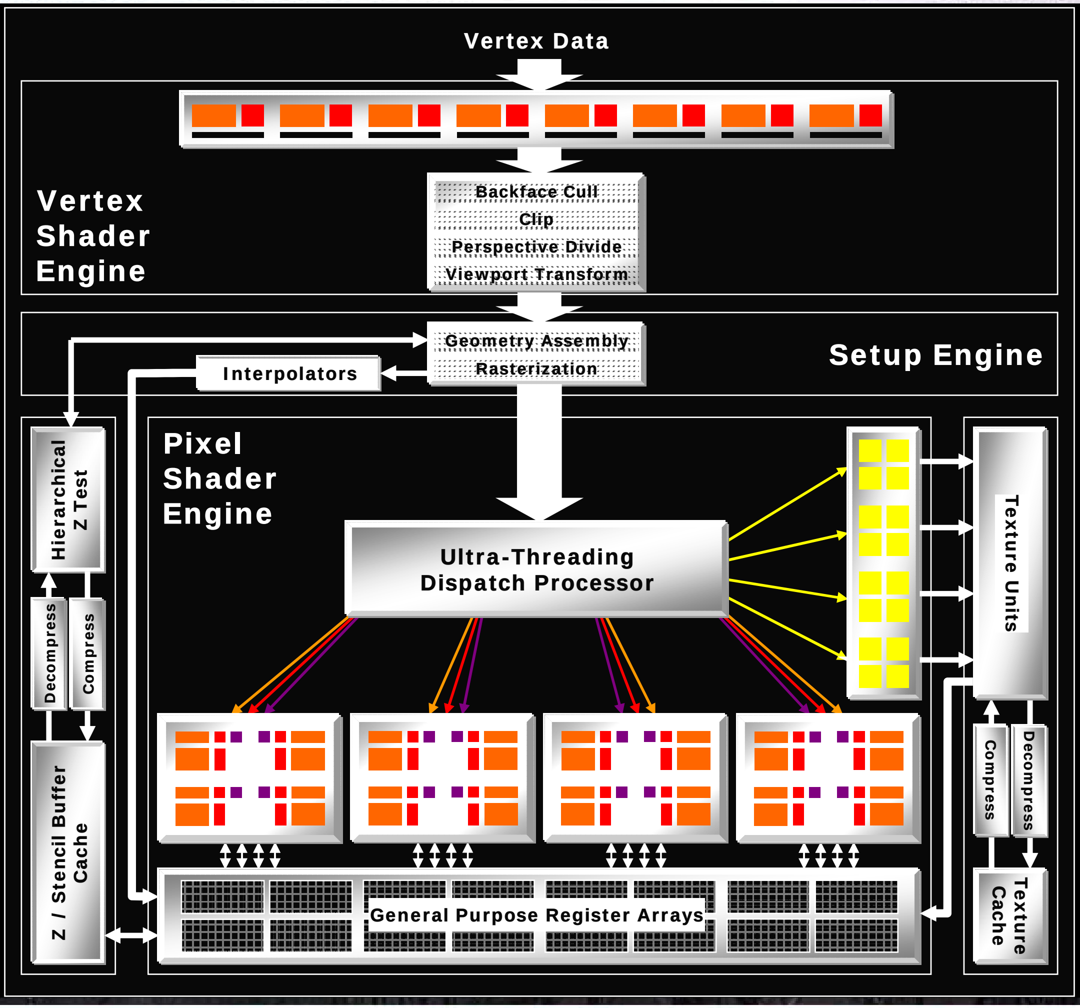
- 16 Pixel Shader Processors
  - Ultra-Threading Dispatch Processor
  - 4 Shader Cores
- 8 Vertex Shader Processors
- 16 Texture Address Units
- 16 Texture Units
- 16 Render Back-End Units



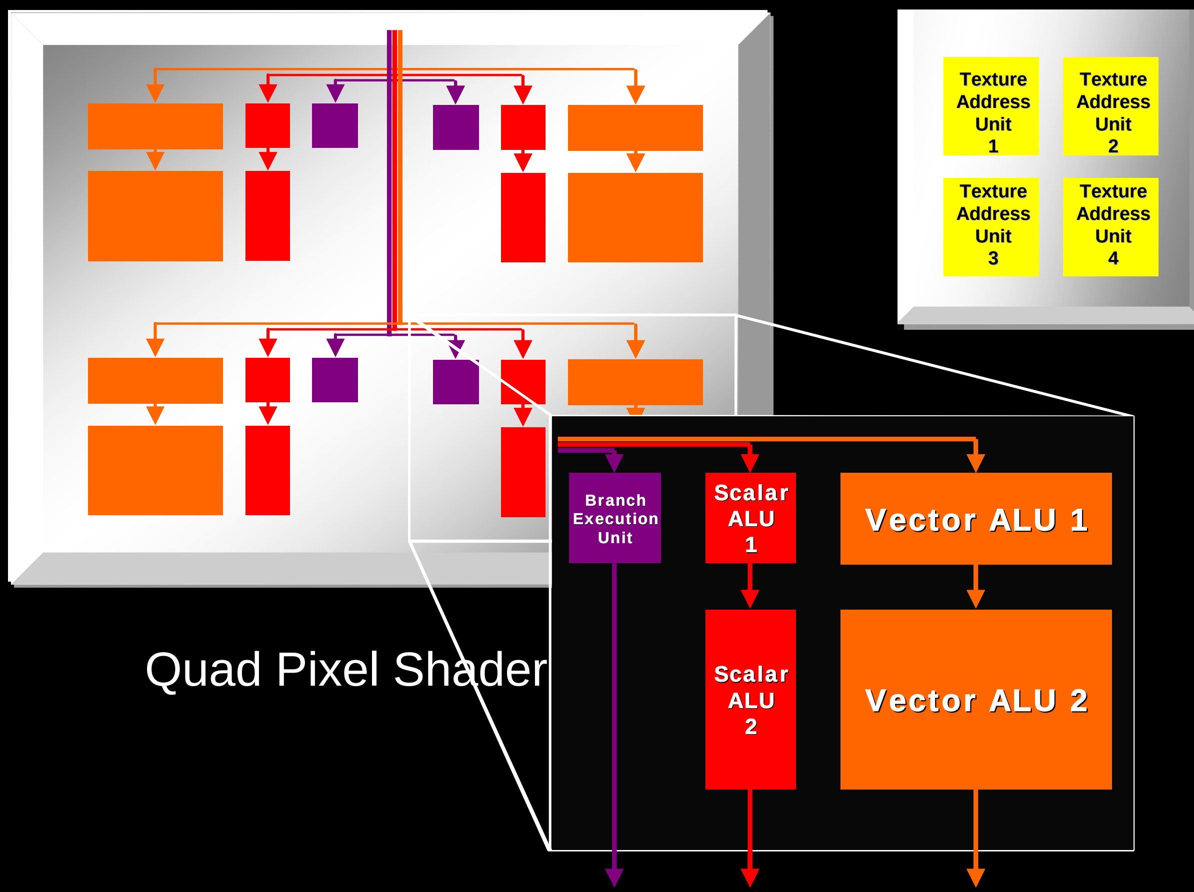
Radeon X1800 Shader Engines



Radeon X1800 Shader Engines



Pixel Shader Processors



Texture Address Units

1 texture address instructions per unit per clock cycle

Pixel Shader Processor
Per Clock Cycle:

1 vec3 ADD + input modifier
1 scalar ADD + input modifier
1 vec3 ADD/MUL/MADD
1 scalar ADD/MUL/MADD
1 flow control instruction

Shader Model 3.0 Key Features

- Dynamic Flow Control
  - Branching (IF...ELSE), Looping, Subroutines
- 128-bit Floating Point Processing
  - For pixel and vertex shaders
- Longer Shaders
  - Billions of instructions possible with flow control

Dynamic Flow Control

- Allows different paths through the same shader to be executed on adjacent pixels
- Provides significant optimization opportunities
  - Skip parts of a shader that don't need to be executed ("early out")
  - Avoid state change overhead by combining multiple related shaders into a single one
  - Allows GPU to execute CPU code more effectively
- Can interfere with parallelism
  - Redundant computation can often reverse any benefits of using flow control

Accelerating Flow Control

- Large number of threads
- Intelligent thread selection
- Small thread size
- Dedicated flow control logic

Ultra-Threading

Sophisticated, Large Scale Multi-Threading

- Hundreds of simultaneous threads across multiple cores
- Each thread can perform up to 6 different shader instructions on 4 pixels per clock cycle

Small Thread Sizes

- 16 pixels per thread in Radeon X1800
- Fine-grain parallelism

Fast Branch Execution

- Dedicated units handle flow control with no ALU overhead

Large, Multi-Ported Register Arrays

- Enables fast thread switching

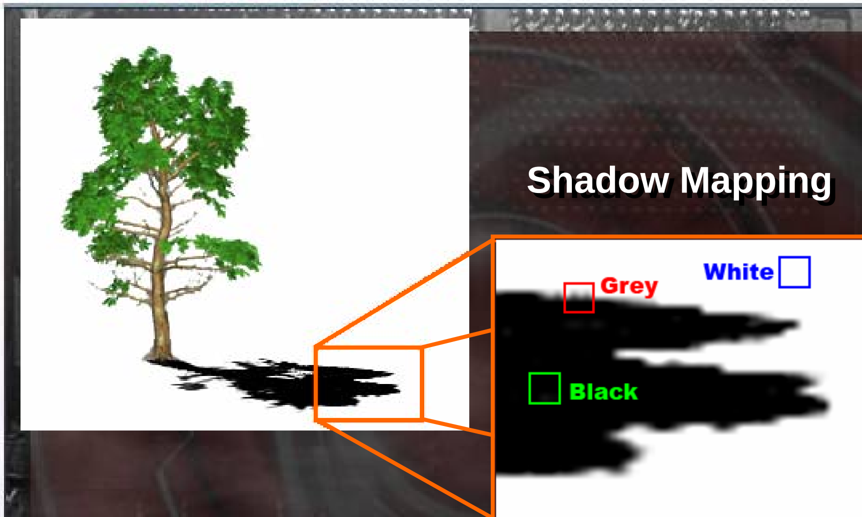
Ultra-Threading Benefits

Hides texture fetch latency

Minimizes shader processor idle time and wasted cycles

Accelerates dynamic flow control with SM3.0

Thread Size and Dynamic Branching Efficiency

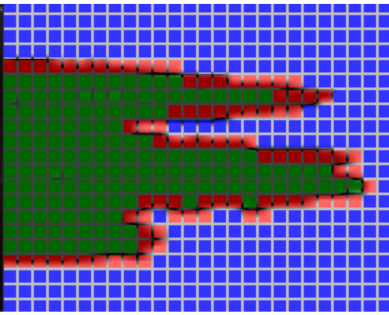



```
.
// Sample Shader
 if(shadow)
 {
   Process □,▣
 }
 else
 {
   Process ■,▣
 }
.
```

Does not take advantage of dynamic branching

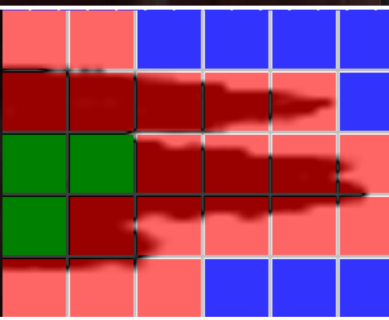
Thread Size
4x4
(16 pixels)

Efficient



Thread Size
16x16
(256 pixels)

Less Efficient

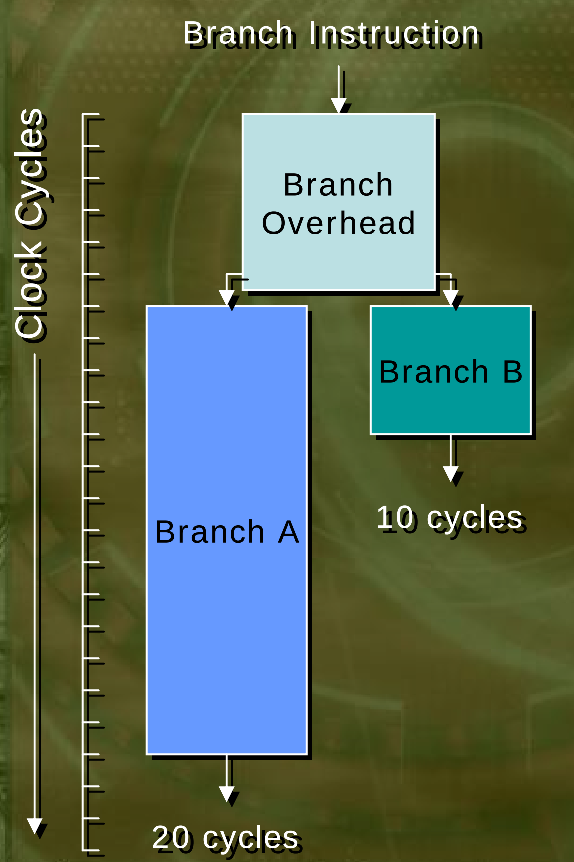


Thread Size
64x64
(4096 pixels)

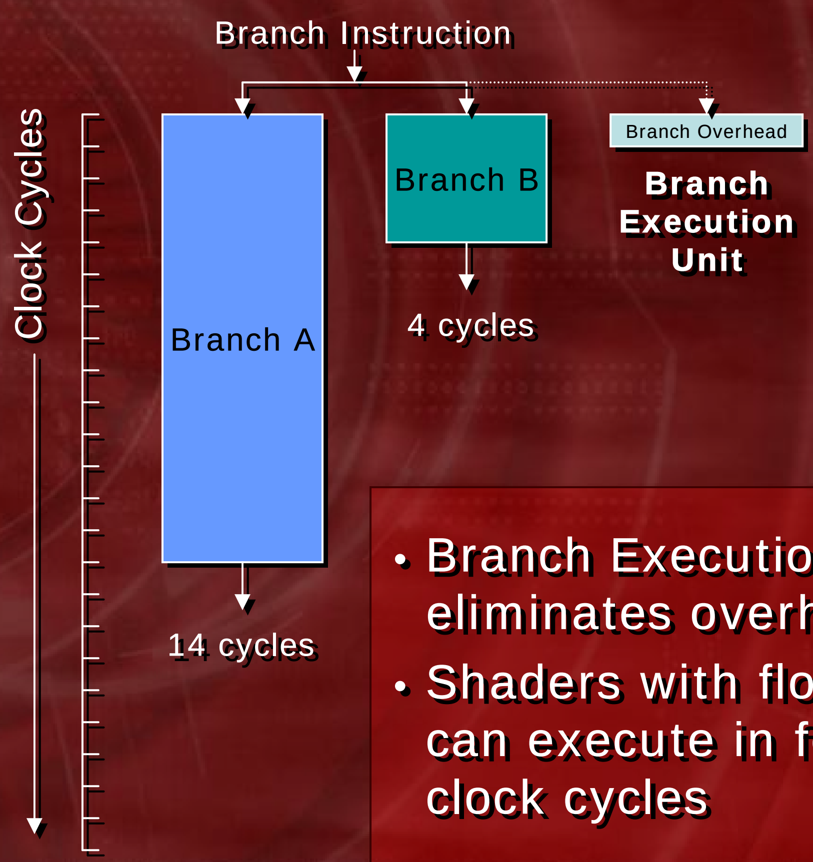
Inefficient

Fast Branch Execution

Traditional Architecture



Ultra-Threaded Architecture



- Branch Execution Unit eliminates overhead
- Shaders with flow control can execute in fewer clock cycles

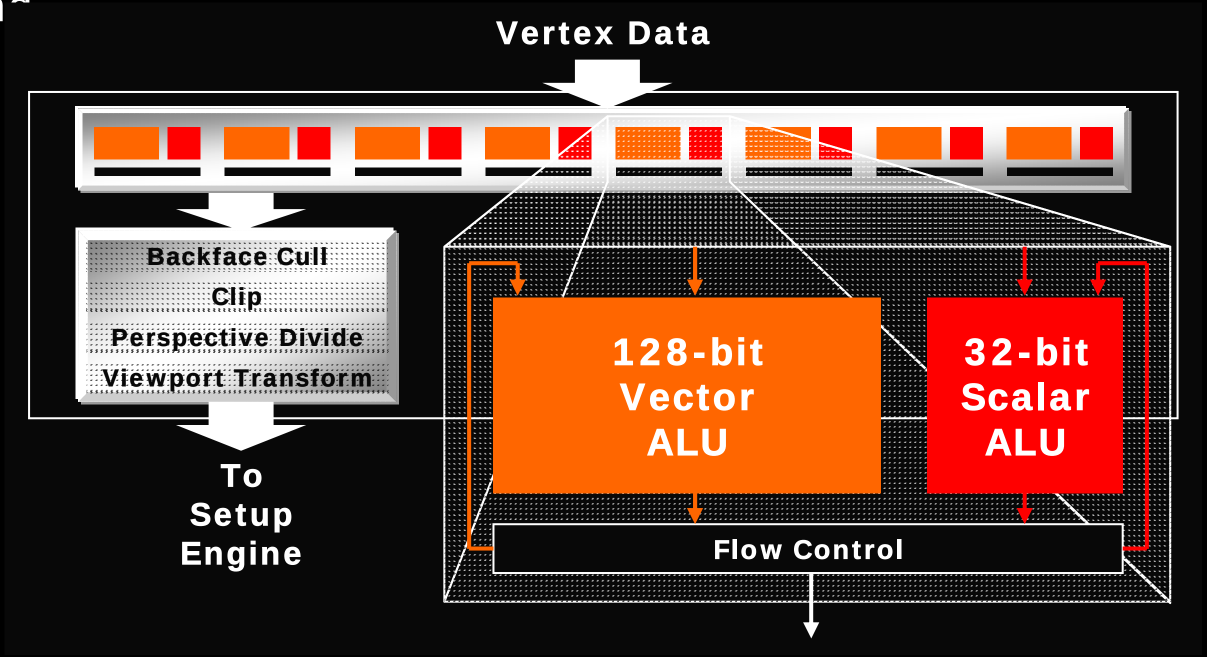
128-bit Floating Point Processing

- Optimal performance without reducing precision
  - General Purpose Register Array has ample storage and read/write bandwidth
  - All shader calculations use 128-bit floating point precision, at ***full speed***
- Effective handling of non-pixel operations

  Examples:
  - Vertex processing – render to vertex buffer
  - Parallel data processing – off-loading work from CPU
- Maintains precision in long shaders

Vertex Engine

- 8 Vertex Shader Processors
  - Each can handle 2 shader instructions per clock
  - 10 billion instructions per second
- Upgraded to support SM3.0
  - Dynamic flow control
  - 1,024 instructions (practically unlimited with flow control)
  - More temporary registers



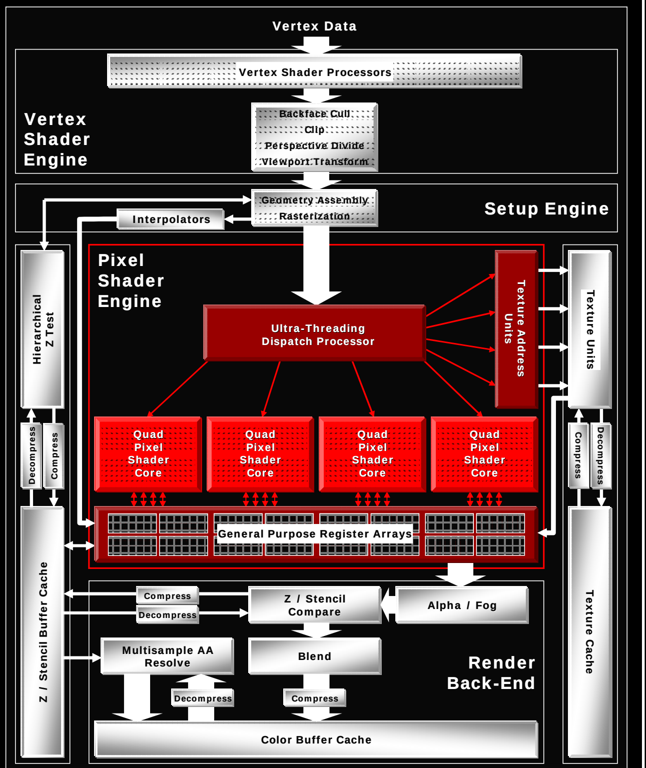
Flexible Architecture

- Focus on shader processing
  - Primary performance indicator for games going forward
- Radeon X1000 architecture de-couples components of the rendering pipeline
  - Allows greater flexibility in GPU design
  - Number of each component can be varied independently
  - More optimal design choices for any given silicon budget

	Pixel Shader Processors	Vertex Shader Processors	Texture Units	Render Back-Ends	Z Compare Units	Max. Threads
Radeon X1800	**16**	8	16	16	16	512
Radeon X1600	**12**	5	4	4	8	128
Radeon X1300	**4**	2	4	4	4	128

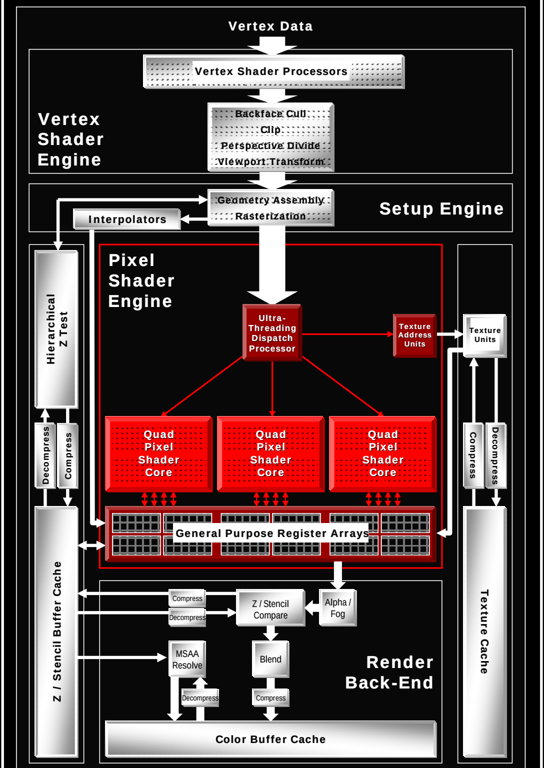
3D Architecture Comparison

Radeon X1800



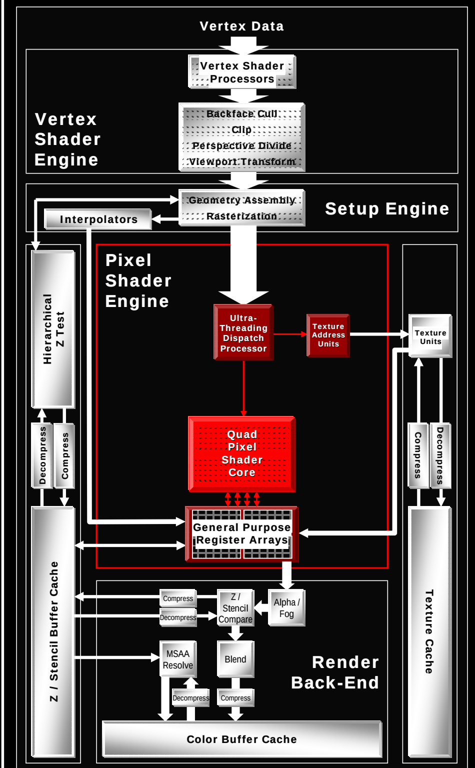
16 Shader Processors

Radeon X1600



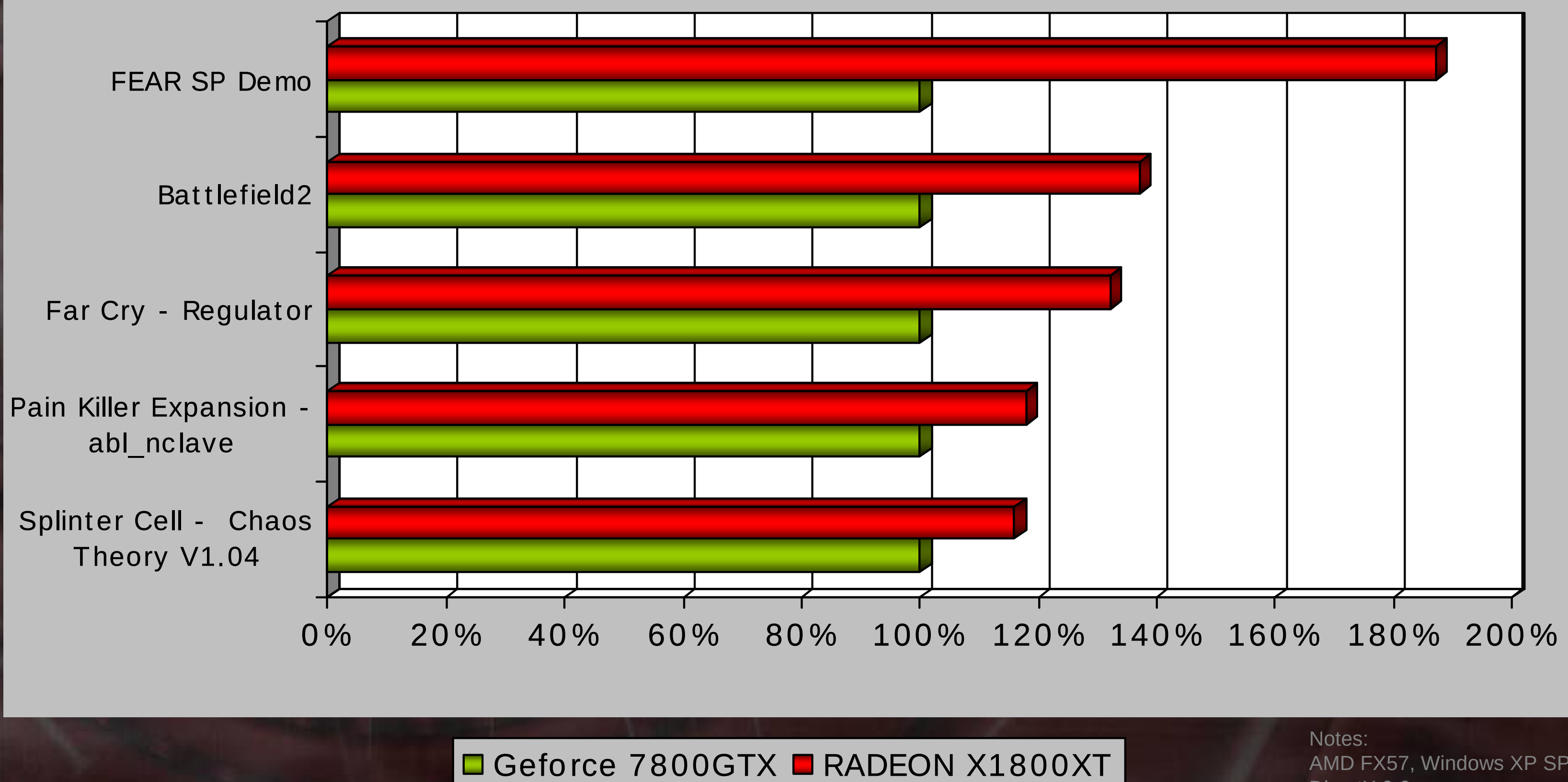
12 Shader Processors

Radeon X1300



4 Shader Processors

Shader Model 3.0 Done Right



Notes:
AMD FX57, Windows XP SP2, DirectX 9.0c
Xpress200P chipset 1GB
1600x1200 4XAA & 8XAF

3D Architecture Summary

- Ultra-Threaded Pixel Shader Engine
- Efficient Dynamic Flow Control
- Full Speed 128-bit Floating Point Processing
- Consistently Fast Shader Model 3.0 Performance
- Flexible, Scalable Design

Toy Shop Demo