



Game Developers Conference

Up Your Game! Know Your Intel GPU Architecture

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Agenda for Today

■ Intel® Graphics Performance Analyzers (Intel® GPA) Overview

■ What's New

■ Execution Unit (EU)

■ Intel® GPA Profiling

■ Summary

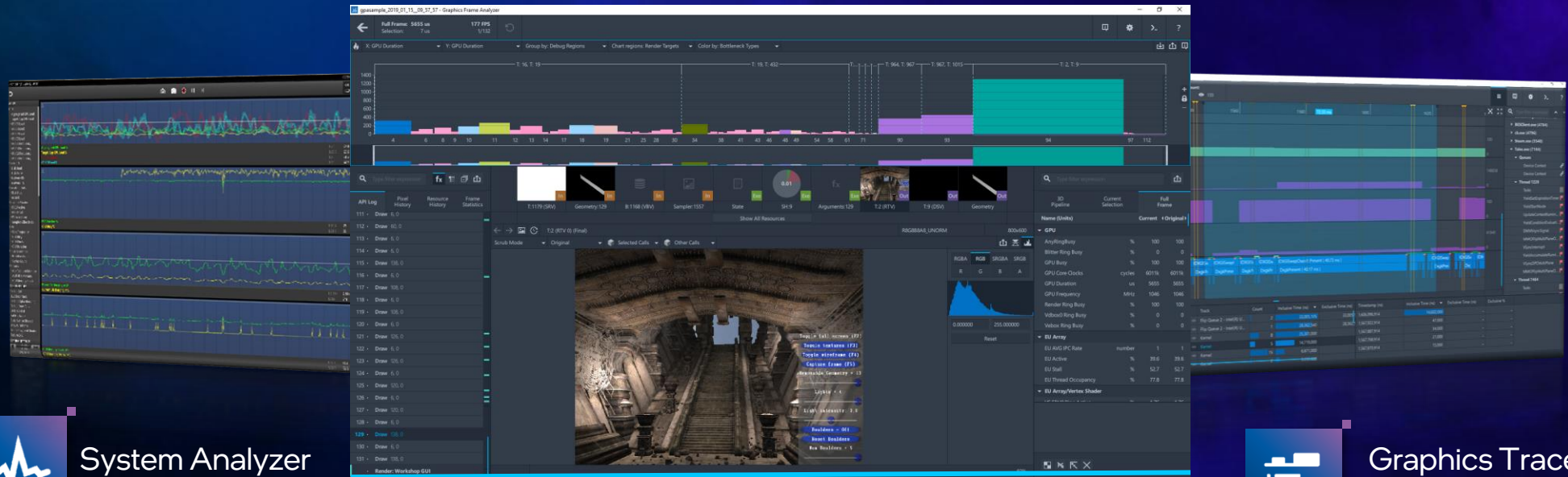
■ Resources




What is Intel® GPA?

Tool suite for analyzing games and other real-time graphics applications.

Locate graphics bottlenecks



 System Analyzer

 Graphics Trace Analyzer

 Graphics Frame Analyzer
Intel® GPA Framework

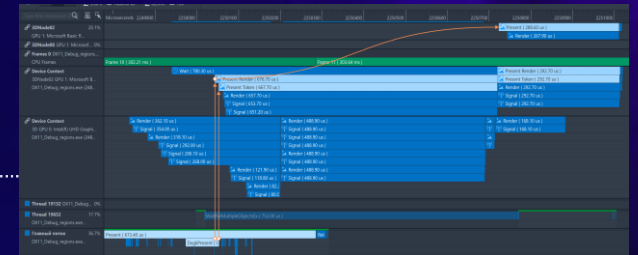


What's New

Multi-GPU support

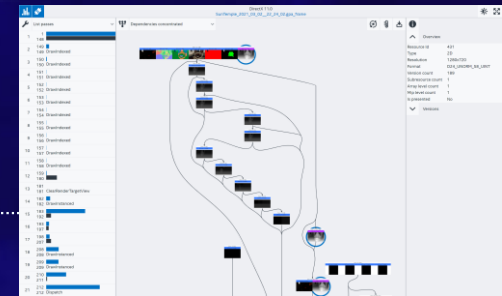
Graphics Trace Analyzer

- Sync highlighting and arrows: Signal, Render, Present packages
- Activity indicators (percent/time)

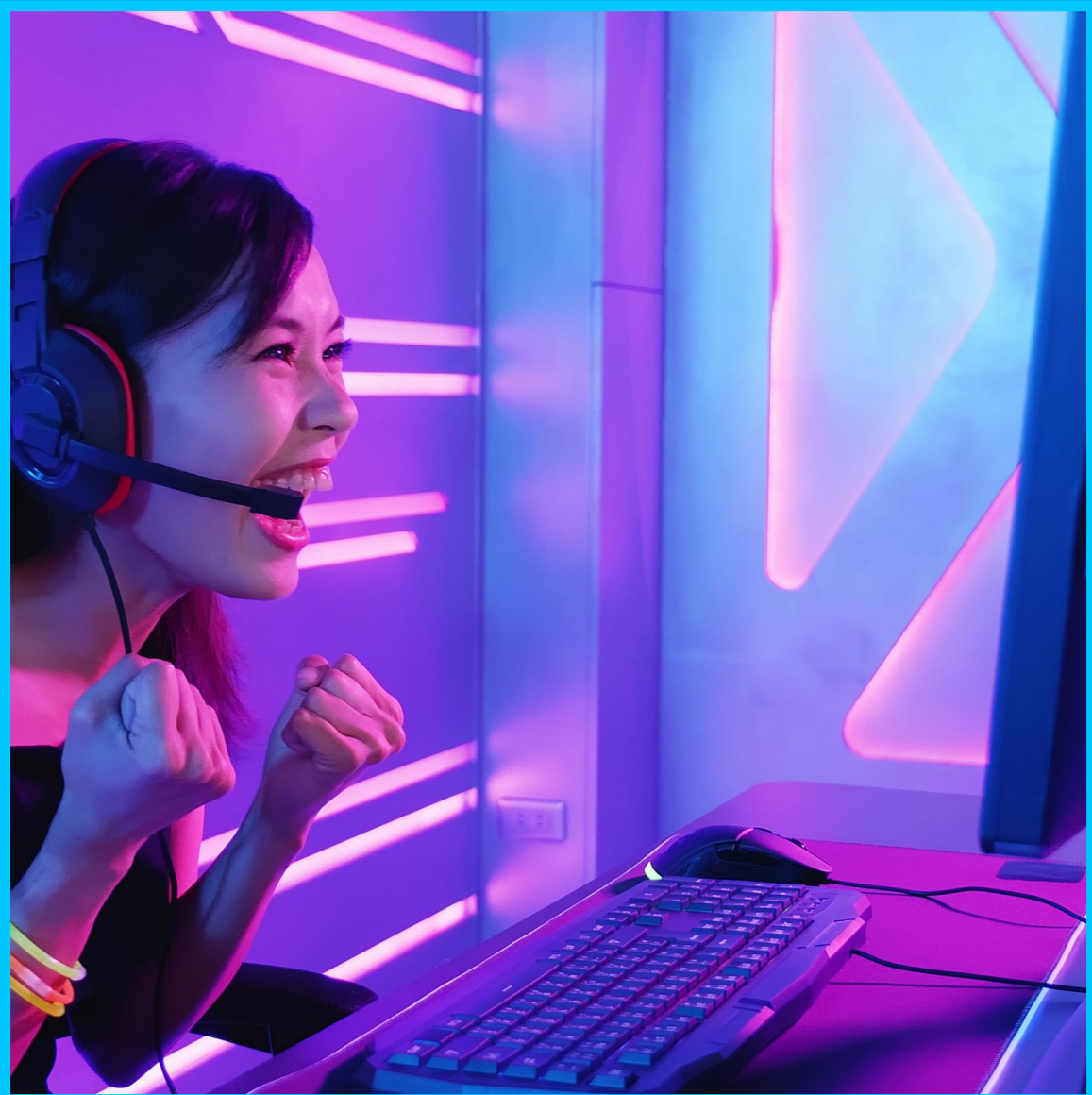


Graphics Frame Analyzer

- Multi-frame support (stream mode)
- Render Target Dependency View for Direct3D 11



Intel® GPA Plugin for Unreal Engine



EU Architecture



Architecture
Overview



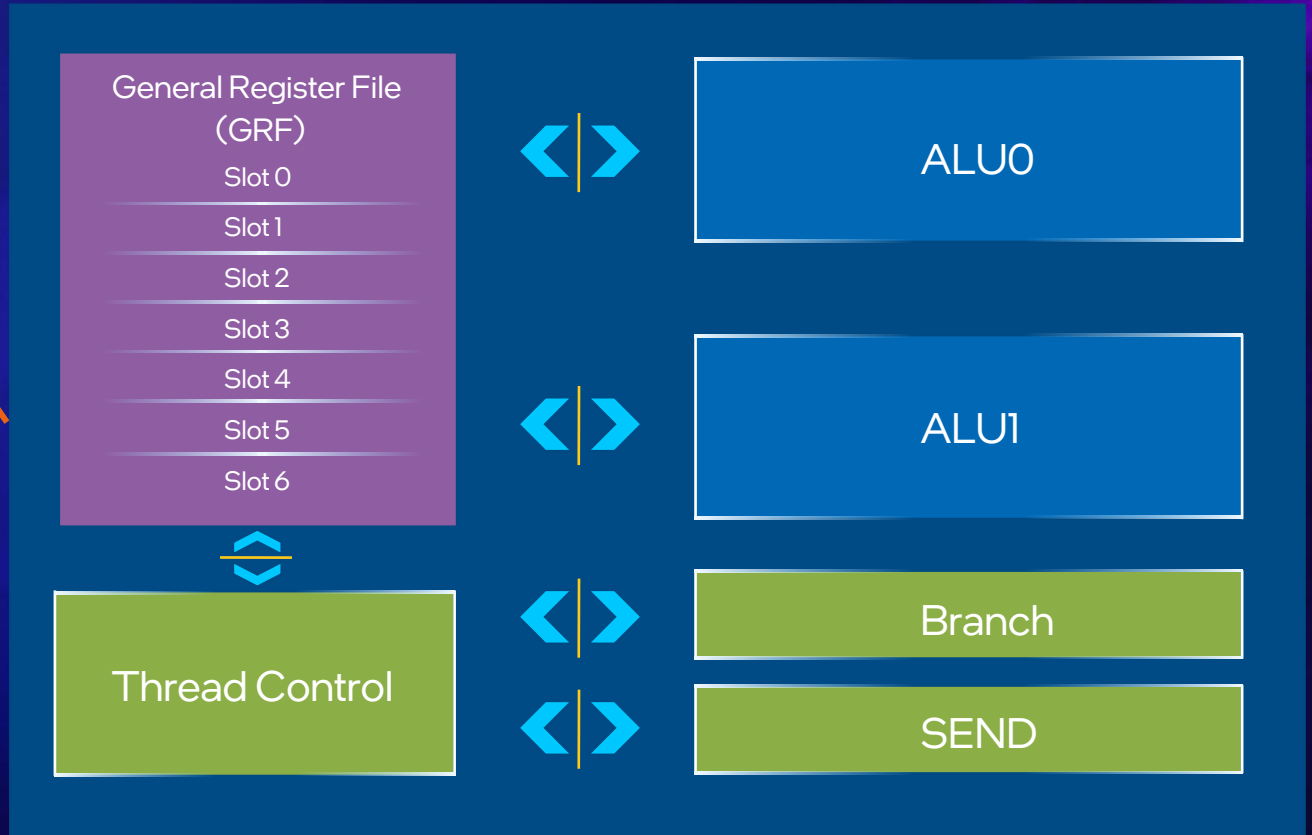
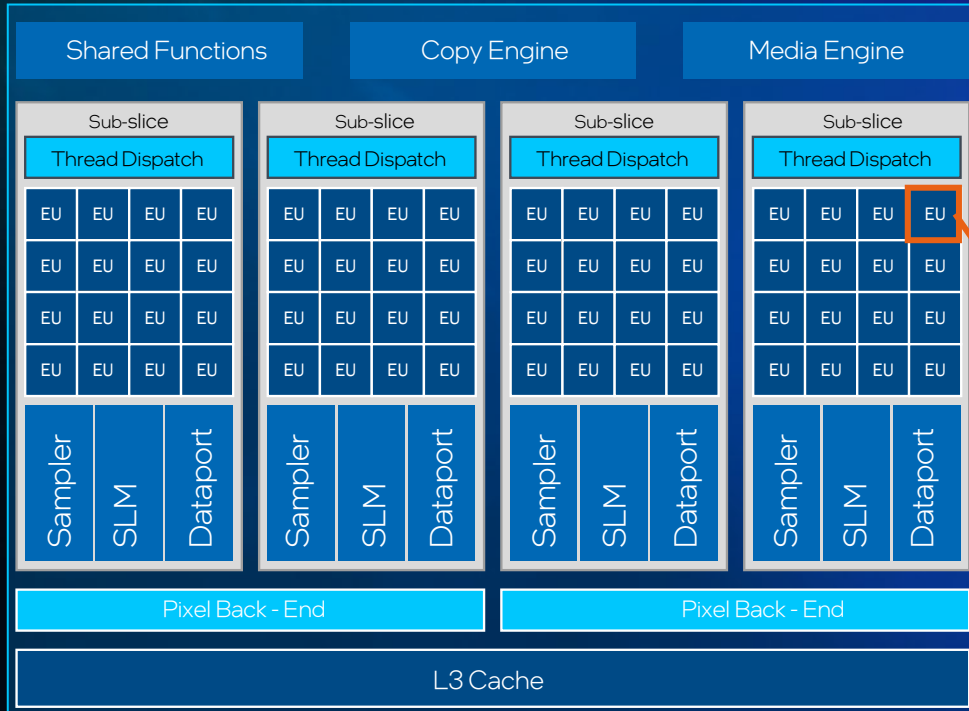
Latency vs.
Stall



Metrics



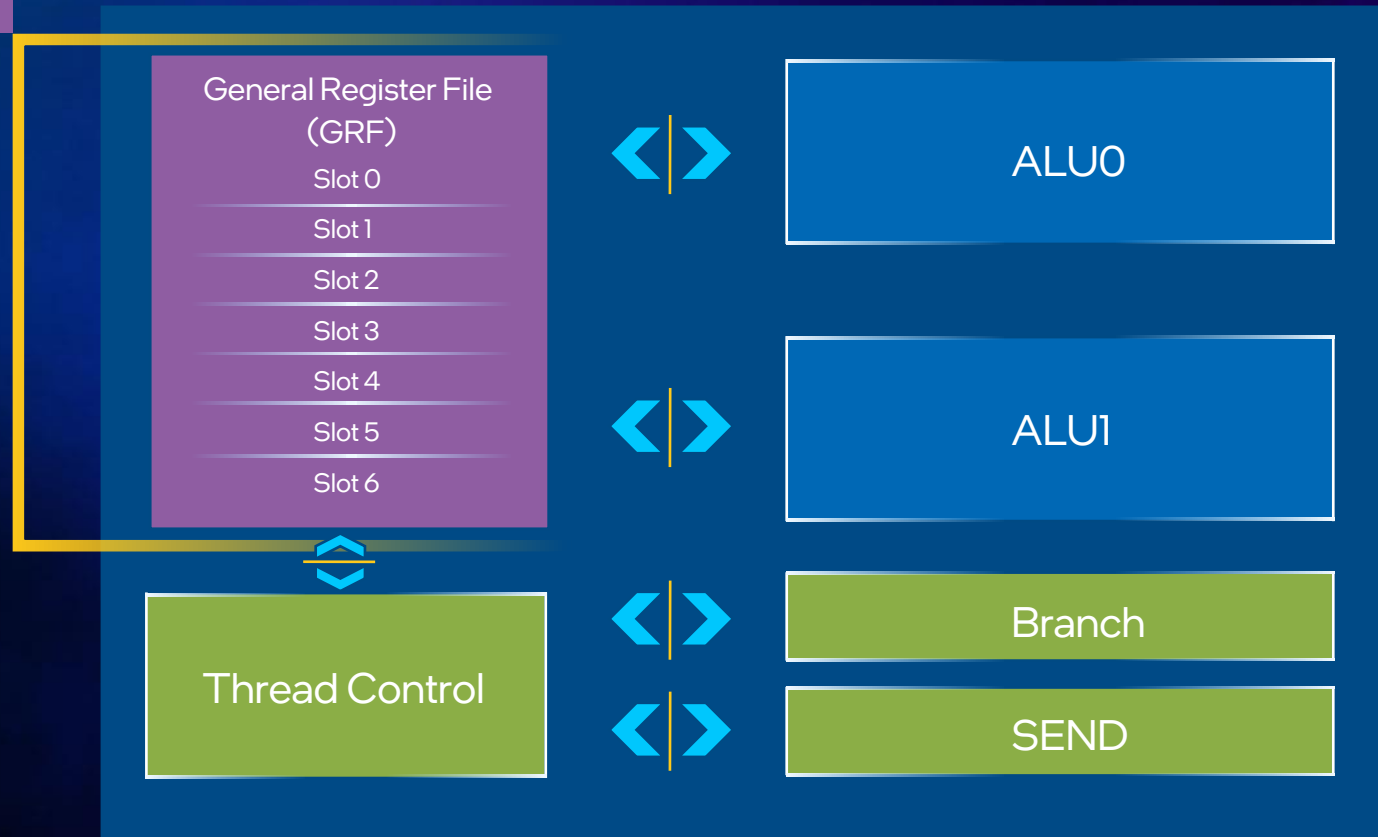
Execution Unit (EU) Overview





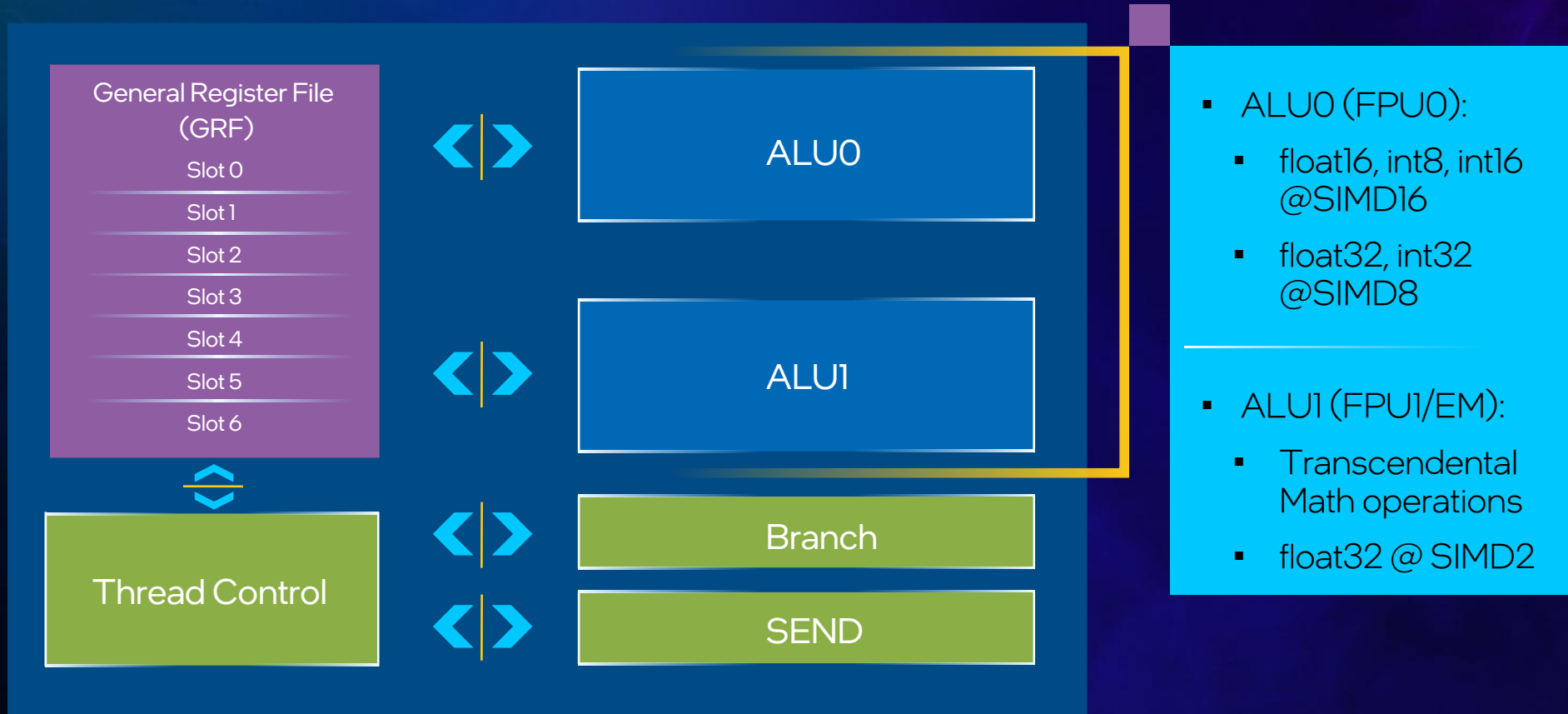
Execution Unit (EU) Overview

- 7 Thread Slots
- 128 registers x 32B = 4KB per Slot
- Each slot can run a different shader
- More threads = more latency hiding



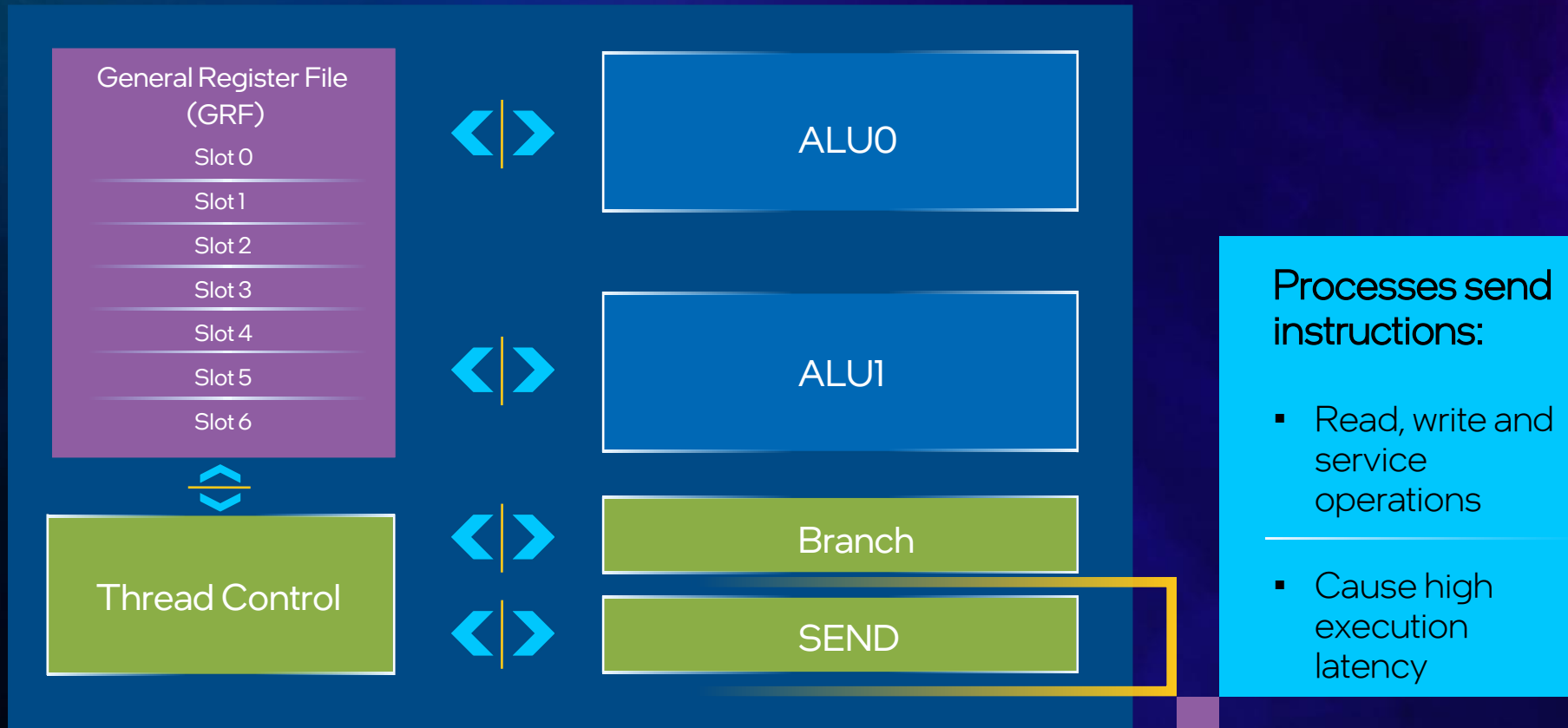


Execution Unit (EU) Overview





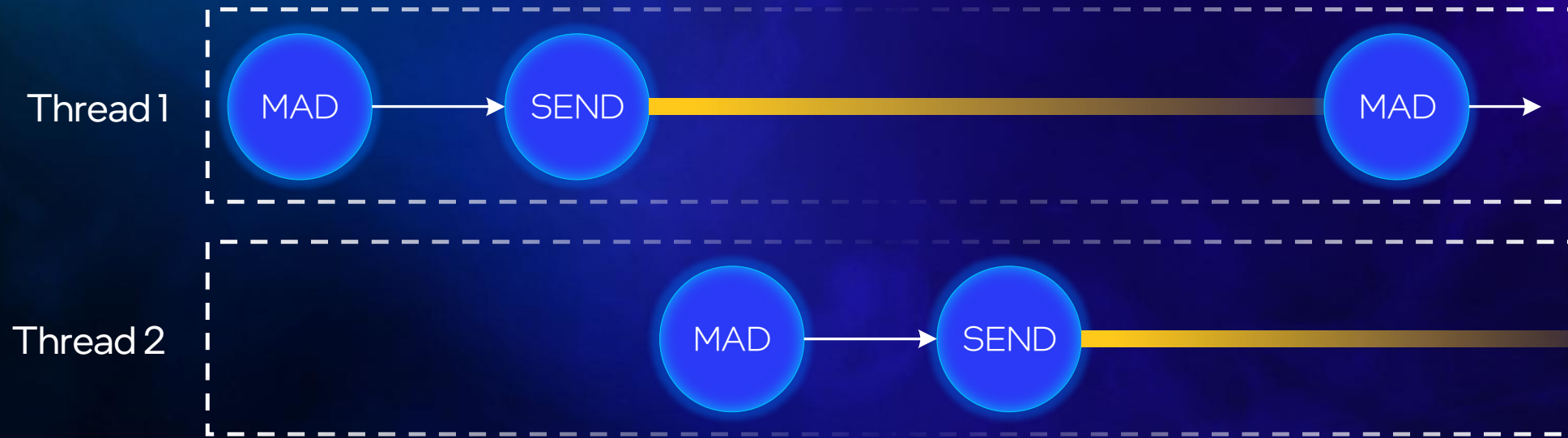
Execution Unit (EU) Overview



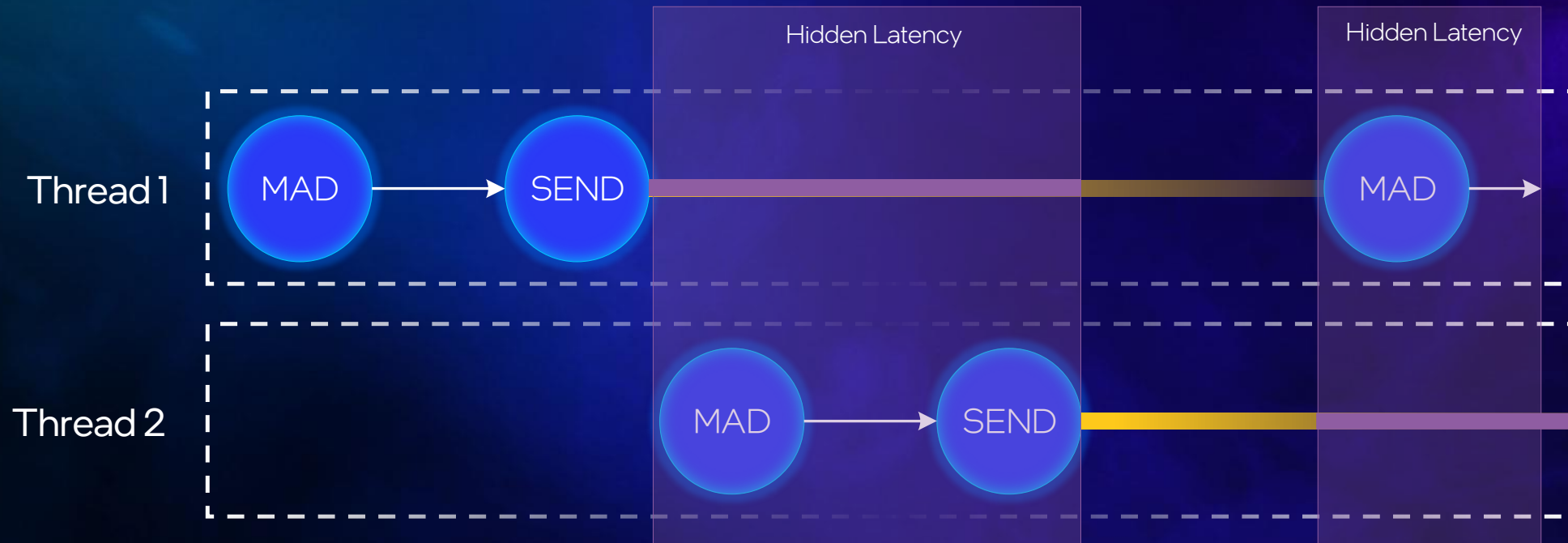
Latency vs. Stall



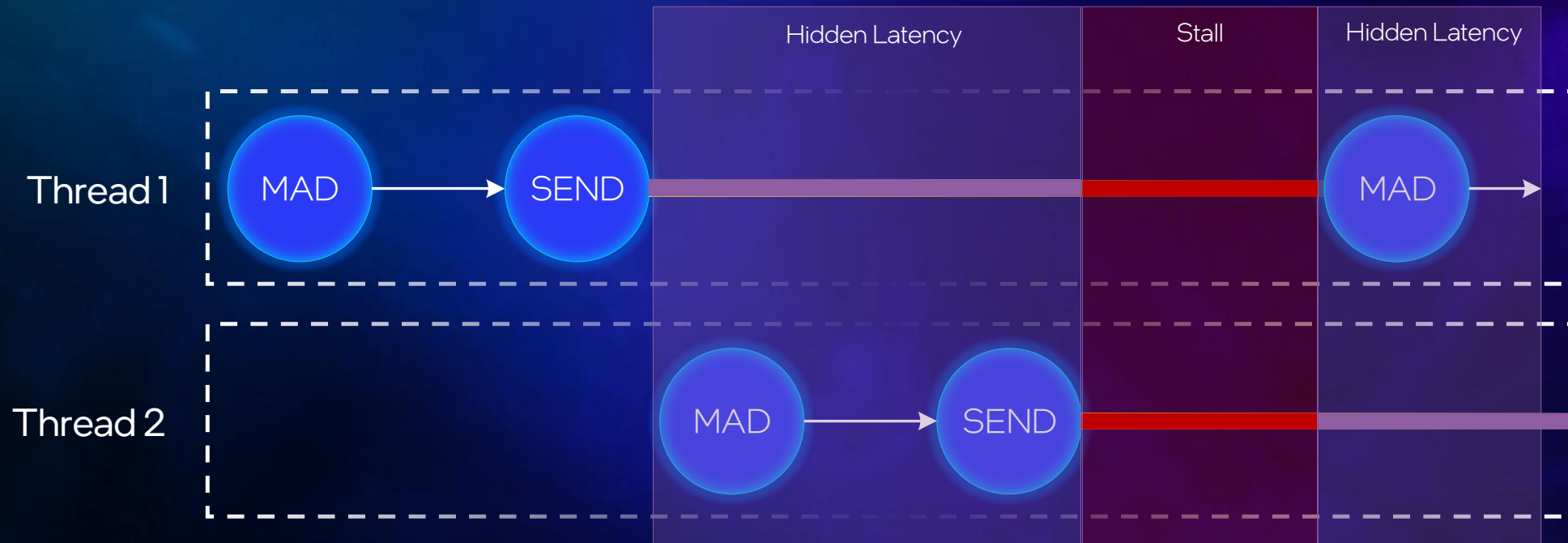
Latency vs. Stall



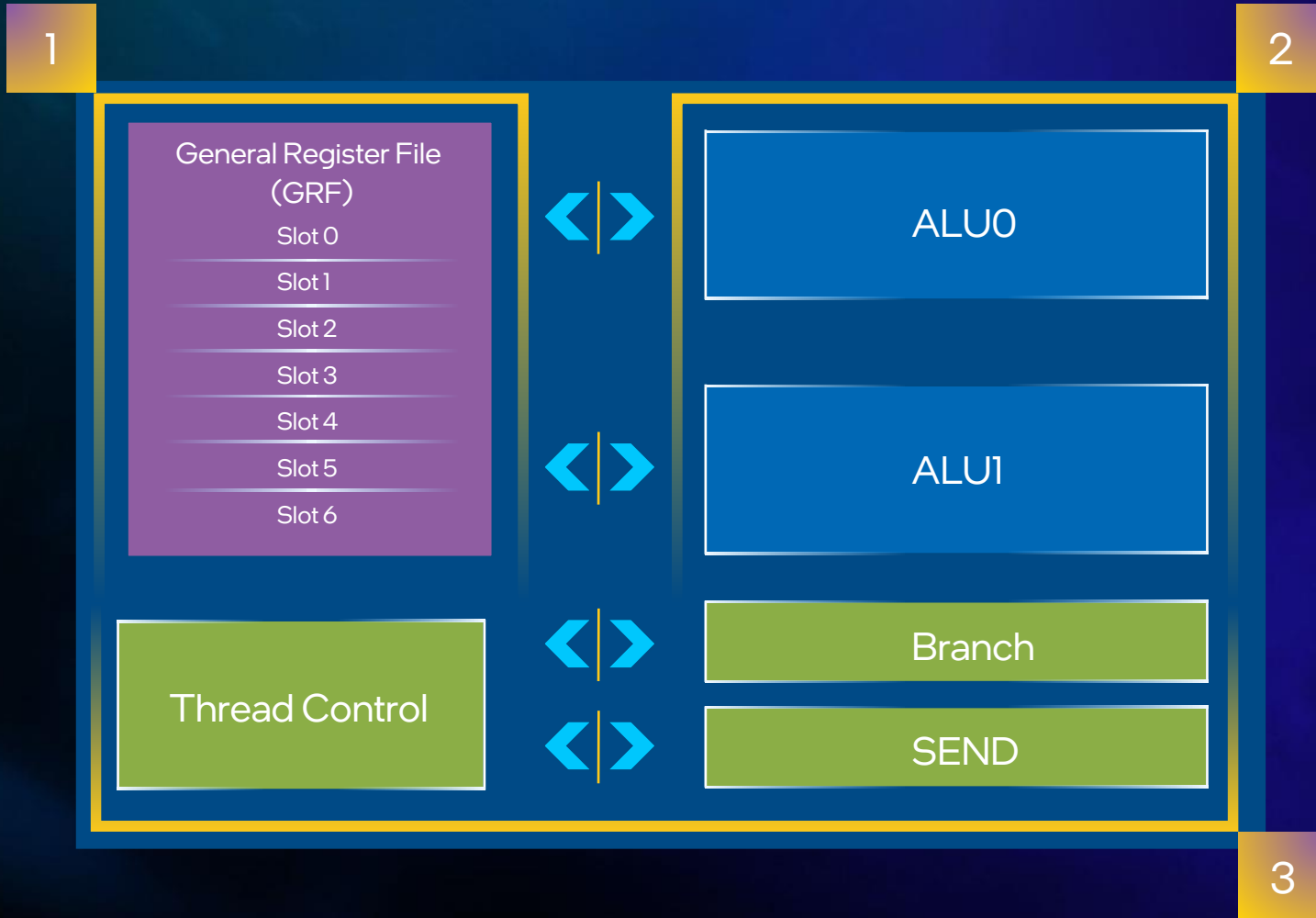
Latency vs. Stall



Latency vs Stall



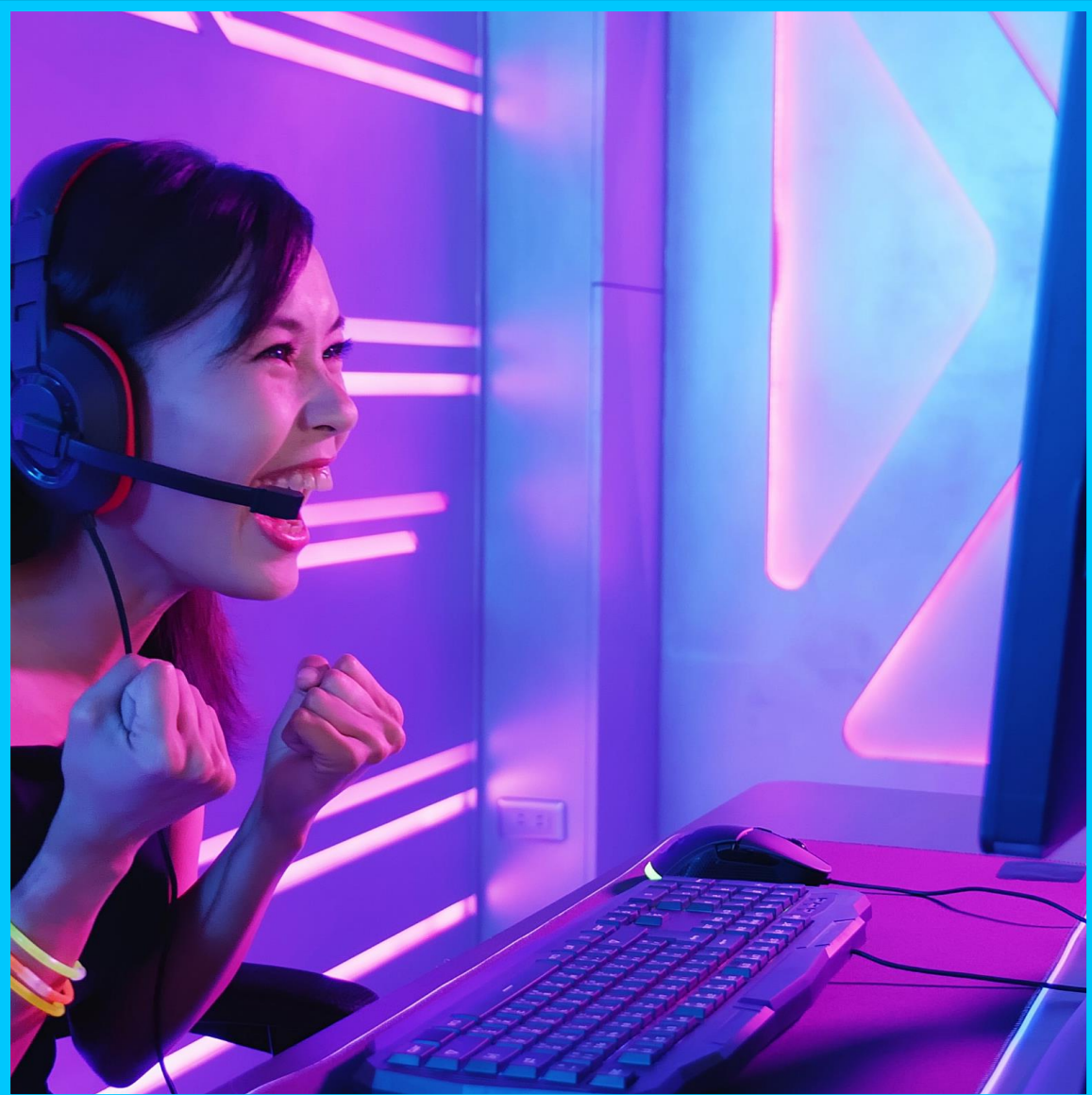
EU Performance Observability



In Graphics Frame Analyzer

Metrics are averaged across all EUs over the time measured:

- 1 EU Thread Occupancy, %** - percent of thread slots in use
- 2 EU Active, %** - ALU0 or ALU1 executing an instruction
- 3 EU Stall, %** - at least one thread loaded, but no instruction executed



Intel[®] GPA Profiling



Hotspot
Analysis

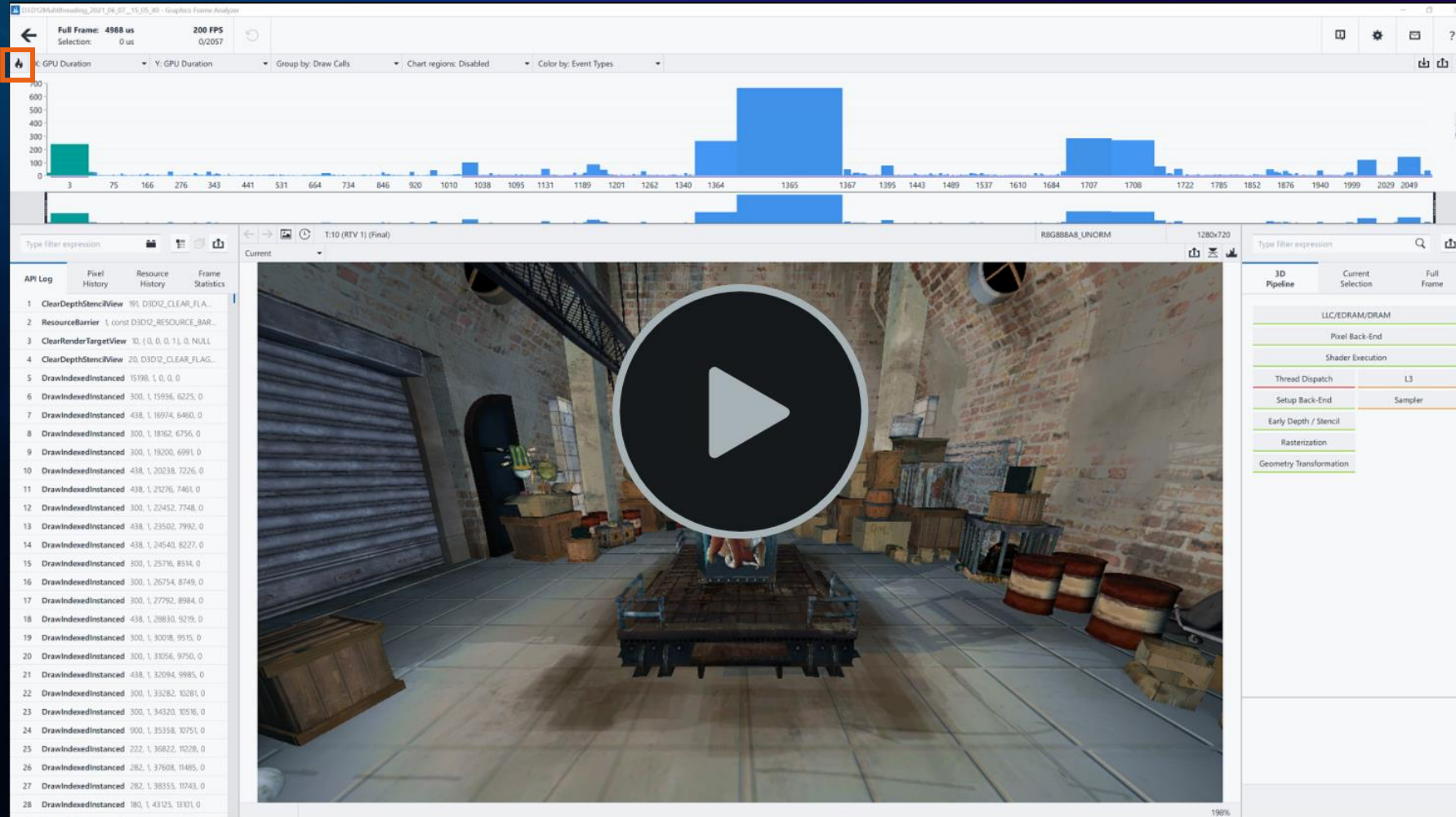


Thread
Dispatch
Problem



Shader
Profiler

Automatic Hotspot Analysis



Hotspot Example: L3 Cache

3D Pipeline	Current Selection	Full Frame
LLC/EDRAM/DRAM		
Pixel Back-End		
Shader Execution		
Thread Dispatch	L3	
Setup Back-End	Sampler	
Early Depth / Stencil		
Rasterization		
Geometry Transformation		
Name (Units)	Current	Original
EU Array		
EU Active	% 79.4	79.4
EU Stall	% 17.4	17.4
EU Thread Occupancy	% 90.5	90.5

EU Active	%	79.4	79.4
EU Stall	%	17.4	17.4
EU Thread Occupancy	%	90.5	90.5

Hotspot Example: L3 Cache

3D Pipeline	Current Selection	Full Frame
LLC/EDRAM/DRAM		
Pixel Back-End		
Shader Execution		
Thread Dispatch	L3	
Setup Back-End	Sampler	
Early Depth / Stencil		
Rasterization		
Geometry Transformation		
Name (Units)	Current	Original
EU Array		
EU Active	% 79.4	79.4
EU Stall	% 17.4	17.4
EU Thread Occupancy	% 90.5	90.5



Duration: SH: 17

HLSL	Type filter expression	ISA simd16	Type filter expression
99	float4 CalcUnshadowedAmountPCF2x2(int lightInde	0.1%	158 (W) mad (16 M0)
100	{	0.1%	159 (W) mad (16 M0)
101	// Compute pixel position in light space.	0.1%	160 (W) mul (16 M0)
102	float4 vLightSpacePos = vPosWorld;	0.02%	161 (W&f1.1) sel (1 M0)
103	vLightSpacePos = mul(vLightSpacePos, lights	0.1%	162 (W) mul (16 M0)
104	vLightSpacePos = mul(vLightSpacePos, lights	0.1%	163 (W) mad (16 M0)
105		0.02%	164 (W) add (1 M0)
106	vLightSpacePos.xyz /= vLightSpacePos.w;	0.1%	165 (W) mad (16 M0)
107		0.1%	166 (W) mov (16 M0)
108	// Translate from homogeneous coords to tex	0.02%	167 (W) add (1 M0)
109	float2 vShadowTexCoord = 0.5f * vLightSpace	0.02%	168 (W) mov (1 M0)
110	vShadowTexCoord.y = 1.0f - vShadowTexCoord.	2.4%	169 sends (16 M0)
111		0.1%	170 (W) mad (16 M0)
112	// Depth bias to avoid pixel self-shadowing	0.02%	171 (W) add (1 M0)
113	float vLightSpaceDepth = vLightSpacePos.z -	0.02%	172 (W) mov (1 M0)
114		2.4%	173 sends (16 M0)
115	// Find sub-pixel weights.	0.02%	174 (W&f0.1) sel (1 M0)
116	float2 vShadowMapDims = float2(1280.0f, 720	0.1%	175 (W) mov (16 M0)
117	float4 vSubPixelCoords = float4(1.0f, 1.0f,	0.1%	176 (W) mad (16 M0)
118	vSubPixelCoords.xy = frac(vShadowMapDims *	0.02%	177 (W) add (1 M0)
119	vSubPixelCoords.zw = 1.0f - vSubPixelCoords	0.02%	178 (W&f0.0) sel (1 M0)
120	float4 vBilinearWeights = vSubPixelCoords.z	2.4%	179 sends (16 M0)
121		0.1%	180 (W) mov (16 M0)
122	// 2x2 percentage closer filtering.	0.02%	181 (W) add (1 M0)
123	float2 vTexelUnits = 1.0f / vShadowMapDims;	0.1%	182 (W) mul (16 M0)
124	float4 vShadowDepths;	2.4%	183 sends (16 M0)
125	vShadowDepths.x = shadowMap.Sample(sampleCl	0.1%	184 mad (16 M0)
126	vShadowDepths.y = shadowMap.Sample(sampleCl	0.02%	185 (W) mov (1 M0)
127	vShadowDepths.z = shadowMap.Sample(sampleCl	0.1%	186 mad (16 M0)
128	vShadowDepths.w = shadowMap.Sample(sampleCl	0.02%	187 (W) mov (1 M0)
129		0.1%	188 mad (16 M0)
130	// What weighted fraction of the 4 samples	0.02%	189 (W) mov (1 M0)
131	float4 vShadowTests = (vShadowDepths >= vLi	0.1%	190 mad (16 M0)
132	return dot(vBilinearWeights, vShadowTests);	0.1%	191 mad (16 M0)
133	}	0.1%	192 frc (16 M0)

Hotspot Example: Shader Execution

3D Pipeline	Current Selection	Full Frame	
LLC/EDRAM/DRAM			
Pixel Back-End			
Shader Execution			
Thread Dispatch	L3		
Setup Back-End	Sampler		
Early Depth / Stencil			
Rasterization			
Geometry Transformation			
Name (Units)	Current	Original	
EU Array			
EU Active	%	95.9	95.9
EU Stall	%	3.03	3.03
EU Thread Occupancy	%	95.8	95.8

EU Active	%	95.9	95.9
EU Stall	%	3.03	3.03
EU Thread Occupancy	%	95.8	95.8

Hotspot Example: Thread Dispatch

3D Pipeline	Current Selection	Full Frame
LLC/EDRAM/DRAM		
Pixel Back-End		
Shader Execution		
Thread Dispatch	L3	
Setup Back-End	Sampler	
Early Depth / Stencil		
Rasterization		
Geometry Transformation		
Name (Units)	Current	Original
EU Array		
EU Active	% 66.3	66.3
EU Stall	% 20.4	20.4
EU Thread Occupancy	% 66.2	66.2

EU Active	%	66.3	66.3
EU Stall	%	20.4	20.4
EU Thread Occupancy	%	66.2	66.2

Hotspot Example: Thread Dispatch

3D Pipeline	Current Selection	Full Frame
LLC/EDRAM/DRAM		
Pixel Back-End		
Shader Execution		
Thread Dispatch	L3	
Setup Back-End	Sampler	
Early Depth / Stencil		
Rasterization		
Geometry Transformation		
Name (Units)	Current	Original
EU Array		
EU Active	% 66.3	66.3
EU Stall	% 20.4	20.4
EU Thread Occupancy	% 66.2	66.2



← → 🕒 🔥 📄 Execution Count ▾ SH: 17

ISA simd8 ✓ ↺ Help Type filter expression

24,262		1 L0:
24,262		2 (W) mov (1 M0)
24,262		3 (W) add (1 M0)
24,262		4 (W) and (1 M0) (ne)f1.0
24,262		5 (W) sends (16 M0)
24,262		6 (W) mov (1 M0)
24,262		7 (W) and (1 M0) (ne)f0.1

← → 🕒 🔥 📄 Execution Count ▾ SH: 17

ISA simd16 ✓ ↺ Help Type filter expression

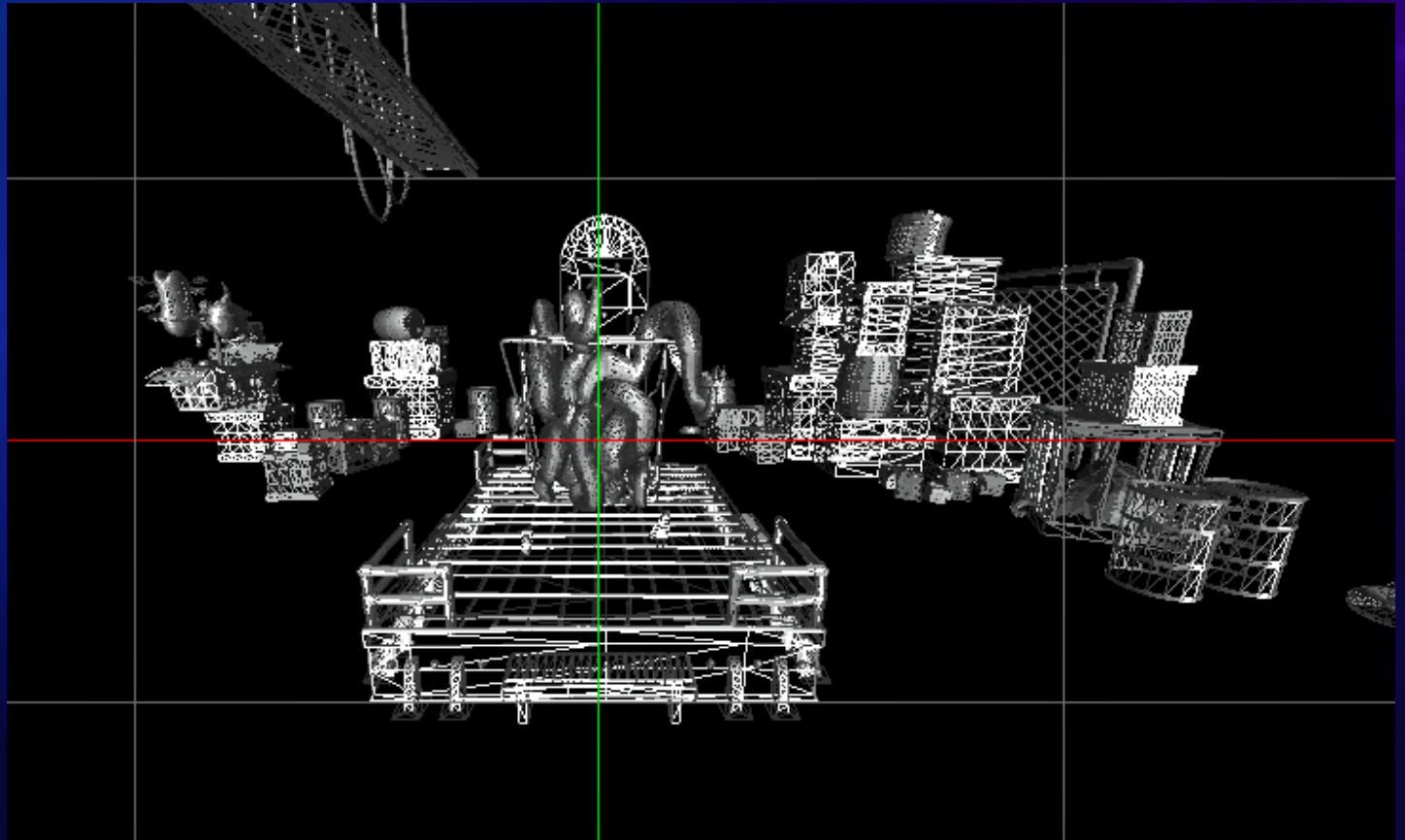
16,234		1 L0:
16,234		2 (W) mov (1 M0)
16,234		3 (W) add (1 M0)
16,234		4 (W) and (1 M0) (ne)f1.0
16,234		5 (W) sends (16 M0)
16,234		6 (W) mov (1 M0)
16,234		7 (W) and (1 M0) (ne)f0.1

Hotspot Example: Thread Dispatch

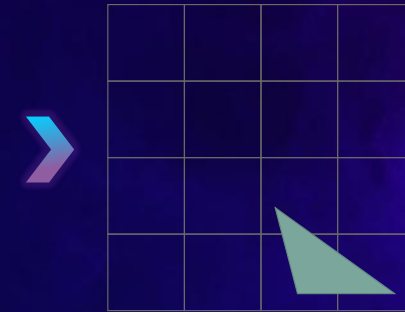
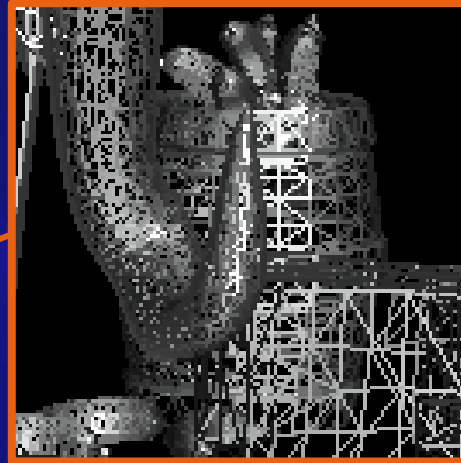
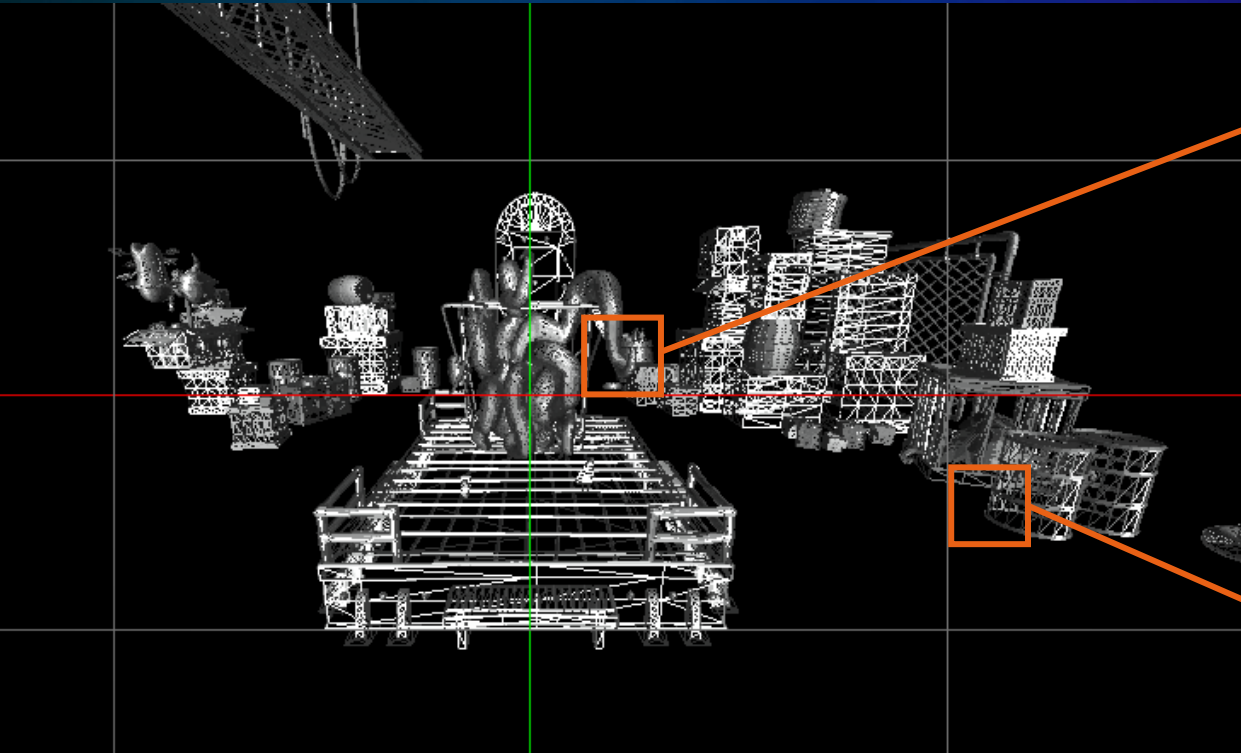
3D Pipeline	Current Selection	Full Frame	
LLC/EDRAM/DRAM			
Pixel Back-End			
Shader Execution			
Thread Dispatch	L3		
Setup Back-End	Sampler		
Early Depth / Stencil			
Rasterization			
Geometry Transformation			
Name (Units)		Current	Original
EU Array			
EU Active	%	66.3	66.3
EU Stall	%	20.4	20.4
EU Thread Occupancy	%	66.2	66.2

Execution Count		SH: 17
ISA simd8		
24,262	1 L0:	
24,262	2 (w) mov (1 M0)	
24,262	3 (w) add (1 M0)	
24,262	4 (w) and (1 M0) (ne)f1.0	
24,262	5 (w) sends (16 M0)	
24,262	6 (w) mov (1 M0)	
24,262	7 (w) and (1 M0) (ne)f0.1	

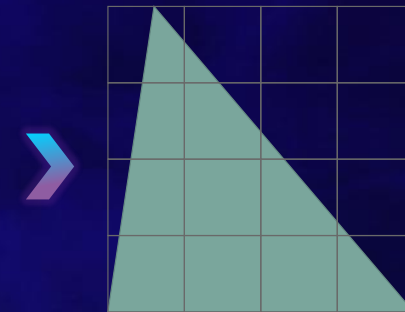
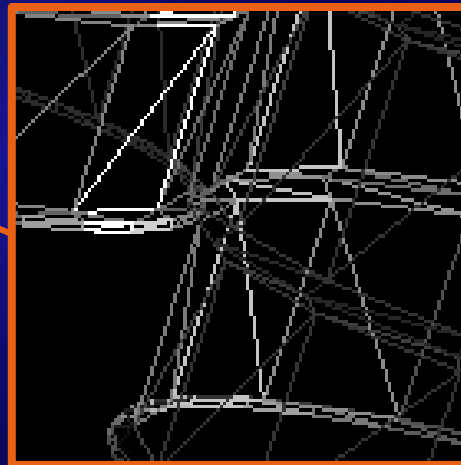
Execution Count		SH: 17
ISA simd16		
16,234	1 L0:	
16,234	2 (w) mov (1 M0)	
16,234	3 (w) add (1 M0)	
16,234	4 (w) and (1 M0) (ne)f1.0	
16,234	5 (w) sends (16 M0)	
16,234	6 (w) mov (1 M0)	
16,234	7 (w) and (1 M0) (ne)f0.1	



Hotspot Example: Thread Dispatch



➤ SIMD8



➤ SIMD16

Up Your Game!

Understand
Your
Hardware

+

Understand
Your Profiler



**Help
Increase
Performance**

Resources

- Intel® Graphics Performance Analyzers

- Product Site – Overview, features, what's new...

- software.intel.com/gpa

- Training – Tutorials, Quick tips, Articles, Workshops

- software.intel.com/gpa/training

- Support – Connect with experts in community forums

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