

# AMD GPU Performance Revealed

Radeon<sup>™</sup> GPU Profiler Microsoft<sup>®</sup> PIX for Windows Radeon<sup>™</sup> GPU Analyzer

Rodrigo Urra, Amit Ben-Moshe

**Advanced Micro Devices, Inc.** 

#### AGENDA

#### Radeon<sup>™</sup> GPU Profiler Rodrigo Urra

Introduction

Tour of last year

What's new and coming

# What is Radeon GPU Profiler?

#### **GPU performance analysis tool**

- Shows low level profiling data
- Visualizes GPU workloads
- Designed to identify performance bottlenecks
- Helps bridge the gap between explicit APIs and GCN

#### **Designed to support**

- Linux<sup>®</sup> and Windows<sup>®</sup>
- Vulkan<sup>®</sup> and DirectX<sup>®</sup> 12



# GDC 2018 - RGP 1.2

#### **Overview**

- Frame summary
- Most expensive events
- Barriers
- Context rolls

#### **Events**

- Wavefront occupancy
- Event timing
- Pipeline state

#### **RenderDoc interop**



System activity									
Visualize command buffer subn	nission and synchronization primitives.	r.	r						
<ul> <li>GPU-based frames</li> </ul>	Workload views	<ul> <li>CPU submission markers</li> </ul>					Zoom to selection	Reset zoom	$\odot$
Frame 17414	Frame 17415	Frame 17416	Frame 17417	Detailed GPU events	Frame 17419	Frame 17420	Frame 17421	Frame 174	22
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System activity								
Visualize command buffer subm	nission and synchronization primitives.							
✓ GPU-based frames	✓ Workload views	$\checkmark$ CPU submission markers					Zoom to selection	Reset zoom 🕒 🚍
Frame 17414	Frame 17415	Frame 17416	Frame 17417	Detailed GPU events	Frame 17419	Frame 17420	Frame 17421	Frame 17422
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System activity									
Visualize command buffer subn	nission and synchronization primitives.	ſ	ſ						
✓ GPU-based frames	Workload views	CPU submission markers					Zoom to selection	Reset zoom	$\odot$
Frame 17414	Frame 17415	Frame 17416	Frame 17417	Detailed GPU events	Frame 17419	Frame 17420	Frame 17421	Frame 174	22
0.000 µs	15,000.000 µs	30,000.000 µs	45,000.000 μs	60,000.000 µs	75,000.000 µs	90,000.000 µs	105,000.000 µs	120,00	0.000 µs
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ID									
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					Sub	Submit duration:	- Enqueue duration: - GP	Juration: - 12	.,,π17.020 μs

#### RGP 1.2 - Most expensive events

Queue index 0 25

Queue index 0 27

Queue index 0 28

Queue index 0 26

Queue index 0 39

Queue index 0 38

Queue index 0 19

Queue index 0 20

Queue index 0 21

vkCmdDrawIndexed(240, 1, 0, 0, 0)

vkCmdDrawIndexed(861, 1, 0, 0, 0)

vkCmdDrawIndexed(861, 1, 0, 0, 0)

vkCmdDrawIndexed(240, 1, 0, 0, 0)

vkCmdDrawIndexed(59886, 1, 0, 0, 0)

vkCmdDrawIndexed(4356, 1, 0, 0, 0)

vkCmdDrawIndexed(4800, 1, 0, 0, 0)

vkCmdDrawIndexed(4800, 1, 0, 0, 0)

291.748 µs

291.697 µs

291.619 µs

291.590 µs

287.960 µs

283.860 µs

274.255 µs

273.956 us



	Pinr	noi	nt op	timization	candidate	2	
vkCmdDrawInde	exed(4476, 1, 0,	0, 0)	273.667 µs	GBuffer Pass / Opaque Meshes		vs	TCS

GBuffer Pass / Opaque Meshes

CS

CS

FS CS

ES CS

TES GS FS CS

#### RGP 1.2 - Barriers

Show table legends

49	%	of	you	Ir	appli	ation	's I	frame	is	consumed	by	barrie	rs

It is recommended that no more than 5 % of your frame be spent in barriers.

	Invalidate	Flush
Instruction (I)		
Level 1 Constant (K)		
Level 1 Data(L1)	640	
Level 2 (L2)		
Color (CB)		
Depth (DB)	198	198

Event Numbers	Duration	Drain Time	Stalls	Depth/Stencil Decompress	HiZ Range Resummarize	DCC Decompress	FMask Decompress	Fast Clear Eliminate	Init Mask RAM	Invalidated	Flushed	Barrier type	Reason for barrier	^
2399	0.226 µs	0.226 µs	VS PS									APP		
> 24012402	39.771 µs	6.549 µs	FULL					$\checkmark$		K L1 CB DB	CB DB	APP		
2403	1.415 µs	1.415 µs	VS PS CS							L2	L2	APP		
2404	2.937 µs	2.937 µs	DMA							K L1 L2	L2	APP		
2418	63.180 µs	1.662 µs	VS PS CS							L2	L2	APP		
2419	3.013 µs	3.013 µs	DMA							K L1 L2	L2	APP		
> 24202424	205.932 µs	205.932 µs		Image: A start of the start						K L1 L2 DB	L2 DB	APP		
2422	13.099 µs	0.653 µs	CS							K L1		APP		
2423	0.690 µs	0.690 µs	CS							K L1		APP		
2426	0.597 µs	0.000 µs								K L1		DRIVER	Blit synchronization.	
> 24272428	5.729 µs	5.729 µs	FULL			$\checkmark$				L1 L2 CB DB	L2 CB DB	APP		
2430	202.947 µs	0.064 µs	CS									APP		
2431	0.647 µs	0.647 µs								K L1		APP		
2432	0.391 µs	0.391 µs	VS PS CS									APP		
2434	128.990 µs	3.111 µs								K L1 L2 DB	L2 DB	APP		
2435	1.294 µs	1.294 µs	VS PS CS							L2	L2	APP		
2436	1.983 µs	1.983 µs	DMA							K L1 L2	L2	APP		
2438	83.113 µs	2.113 µs	VS PS CS							L2	L2	APP		
2439	2.013 µs	2.013 µs	DMA							K L1 L2	L2	APP		
2453	1.295 µs	0.000 µs								K L1 L2	L2	DRIVER	Blit synchronization.	
> 24542455	16.592 µs	1.235 µs	FULL					$\checkmark$		K L1 CB DB	CB DB	APP		
> 24562457	2.295 µs	2.295 µs	FULL					$\checkmark$		K L1 CB DB	CB DB	APP		
> 24582459	2.272 µs	2.272 µs	FULL					$\checkmark$		K L1 CB DB	CB DB	APP		
> 24602461	2.274 µs	2.274 µs	FULL					$\checkmark$		K L1 CB DB	CB DB	APP		
2462	0.391 µs	0.391 µs	VS PS CS									APP		
2463	2.686 µs	2.686 µs	DMA							K L1		APP		
2464	0.389 µs	0.389 µs	VS PS CS									APP		
2465	1.278 µs	1.278 µs	FULL							K L1 CB DB	CB DB	DRIVER	Before CS color clear.	
2467	2.866.00	0.672 με	<b>105</b>									DRIVER	After CS color clear	

#### Spot potential pipeline bubbles

## RGP 1.2 - Context rolls

#### There were 464 context rolls from 1358 draw calls. That's an average of 2.93 draw calls per context. None of these context rolls were completely redundant. None Low Medium High Max Active Redundant



State which	causes c	ontext rolls					Filter API-states	ρ
State			Context rolls	Redunda	int (	Completely redundant	Exclusive	
rasteri	zerDiscardE	nable	394	394 (10	90%) 6	0%)	0 (0%)	
polygon	Mode		47	47 (100	9%) e	0%)	0 (0%)	
cullMode	2		47	8 (17%)	) 6	0%)	0 (0%)	
frontFa	ce		47	37 (78%	K) e	3 (0%)	0 (0%)	10
depthBia	asEnable		10	0 (0%)	e	3 (0%)	0 (0%)	
depthBia	asClamp		10	10 (100	3%) e	0%)	0 (0%)	
depthBia	asSlopeFact	or	10	0 (0%)	e	3 (0%)	0 (0%)	
lineWid	th		13	11 (84%	K) 6	ð (0%)	0 (0%)	
✓ VkPipeline	Multisample	State						
rasteri	zationSample	25	411	411 (16	90%) e	3 (0%)	0 (0%)	
sampleS	hadingEnable	2	411	411 (10	90%) e	3 (0%)	0 (0%)	
sampleMa	ask		14	14 (100	9%) e	0 (0%)	0 (0%)	
alphaTo	CoverageEnal	ole	14	14 (100	9%) 6	0 (0%)	0 (0%)	~
WkDinolino	anthEtonci	stata						-
Events								
Queue	Event ID	Event			Duration	Stall due to context rolls		^
Queue index 0	1218	vkCmdDrawIndexed(2	88, 1, 0, 0, 0)		545,816 clk	100,857 clk		

Queue index 0	1218	vkCmdDrawIndexed(288, 1, 0, 0, 0)	545,816 clk	100,857 clk
Queue index 0	1220	vkCmdDrawIndexed(1088, 1, 0, 0, 0)	340,743 clk	66,688 clk
Queue index 0	1222	vkCmdDrawIndexed(168, 1, 0, 0, 0)	178,591 clk	65,605 clk
Queue index 0	1216	vkCmdDrawIndexed(1088, 1, 0, 0, 0)	869,080 clk	24,371 clk
Queue index 0	1232	vkCmdDrawIndexed(168, 1, 0, 0, 0)	284,683 clk	4,056 clk
Queue index 0	1476	CmdRenderPassColorClear()	143,713 clk	0 dk
Queue index 0	1422	vkCmdDrawIndexed(18, 1, 0, 0, 0)	57,247 clk	0 dk
Queue index 0	1419	vkCmdDraw(3, 1, 0, 0)	263,956 clk	0 dk
Queue index 0	1416	vkCmdDraw(3, 1, 0, 0)	749,502 clk	0 dk
Oueue index 0	1413	vkCmdDraw(3, 1, 0, 0)	574.735 clk	0 clk

#### Find redundant state changes











## RGP 1.2 - Event timing



Understand the cost of GPU work in your frame

# RGP 1.2 - Pipeline state

Wavefront occupancy	Event timing	Pipeline state			
Collapse tree 🛛 🗸 Group	by user events				Search $\wp$
<ul> <li>Lighting Pass</li> </ul>		^			
<ul> <li>589 CmdRenderPassS</li> </ul>	iync()				
590 CmdInitMask	(Ram()				
591 CmdPreCompute	ColorClear()				
592 CmdRenderPassC	ColorClear()	Input Assembler	VS TCS TES	GS Rasterizer Pre Fragment	FS Post Color CS
593 CmdPostCompute	eColorClear()				
<ul> <li>Ambient</li> <li>E94 vkCmdDrow(</li> </ul>	(3 1 0 0)				
× Particle Systems	(5, 1, 0, 0)				
595 vkCmdDrawl	[ndeved(6144_1_0_0_0)				
596 vkCmdDrawl	Indexed(3072, 1, 0, 0, 0)	Wayofronto and th	a von de		
597 vkCmdDraw	Indexed(3072, 1, 0, 0, 0)	wavemonts and th	lieaus		
598 vkCmdDrawI	Indexed(3072, 1, 0, 0, 0)	Total wavefronts	Total threads	Average wavefront duration	Average threads per wavefront
<ul> <li>Point Lights</li> </ul>		2,335	145,496	12,515 clk	62
599 vkCmdDrawI	Indexed(5760, 1, 0, 0, 0)				
600 vkCmdDrawI	Indexed(5760, 1, 0, 0, 0)				
601 vkCmdDrawI	Indexed(5760, 1, 0, 0, 0)				
602 vkCmdDrawl	Indexed(5760, 1, 0, 0, 0)	Per-wavefront res	ources		
603 vkCmdDrawl	Indexed(5/60, 1, 0, 0, 0)	Vector registers	Scalar registers	Uses scratch memory	
604 vkCmdDraw	Indexed(5/60, 1, 0, 0, 0)	22 (22 allocated)	68 (80 allocated)		
606 vkCmdDrawl	[ndexed(5760, 1, 0, 0, 0)]	Sz (Sz allocated)	08 (80 allocated)	U OFF	
607 vkCmdDrawl	[ndexed(5760, 1, 0, 0, 0)]				
608 vkCmdDrawl	Indexed(5760, 1, 0, 0, 0)				
609 vkCmdDraw	Indexed(5760, 1, 0, 0, 0)	Theoretical wavef	ront occupancy		
610 vkCmdDrawI	Indexed(5760, 1, 0, 0, 0)	Incorected waver	Tone occupancy		
611 vkCmdDrawI	Indexed(5760, 1, 0, 0, 0)	The occupancy of this sha	der is limited by its vector register usag	ae.	
612 vkCmdDrawI	Indexed(5760, 1, 0, 0, 0)	This shader could potentia	ally run 8 wayefronts out of 10 wayefron	nts per SIMD	
<ul> <li>613 CmdRenderPassS</li> </ul>	iync()	This shader could potentia		his per strib.	
614 CmdFastClea	arEliminate()				
<ul> <li>Refraction Pass</li> </ul>					
✓ 615 CmdRenderPassS	Sync()				
616 CmdInitMask		However, if you reduced v	ector register usage by 4 you could run	n another wavefront.	
617 ChidPrecomputed	ColorClear()				
619 CmdPostCompute					
<ul> <li>Composite Buffer C</li> </ul>	ODV				
620 vkCmdDraw(	(3, 1, 0, 0)				
<ul> <li>Transparent Meshe</li> </ul>	S	<b>&gt;</b>			

Expose pipeline state and GPR consumption

#### RGP 1.2 - RenderDoc $\leftarrow \rightarrow$ RGP interop



Understand correlation between rendered scene  $\leftarrow \rightarrow$  GPU work

# Cool, but I want more!

#### What about

- Wavefront shader execution?
- How do my shaders translate to GCN ISA?
- Can you give me information about my render targets?
- Enhanced user marker visualization?
- -What if I'm a compute-only developer?

## So what's new?

#### GDC 2018

RGP 1.2 RenderDoc interop

## So what's new?

# GDC 2018

RGP 1.3



Render & depth targets

## So what's new?

#### GDC 2018

RGP 1.2 RenderDoc interop





Render & depth targets





OpenCL<sup>™</sup> support

#### So what's new?



24 GDC 2019

										Zoom te	selection Reset zoom	
	Color pass #0	Compute pass #0	Depth pass #0		Depth pass #1	D	epth pas	Color pas	s #8	Color pass #9		Color pass #10
13,8	75.000 μs	14,250.000 µs	14,625.000 µs	1	L5,000.000 μs		15,375.000 µs	15,750.000 µs	16,125.	.000 μs 16,500.000 μs	16,875.000	μs
			unhunuh		mmml						tu u u u u u u u u u u u u u u u u u u	muliuu
Color												
							Col	or PT #2				
Colo	or RT #2					C	Lolor RT #3 Color R	RT #3				
Colo	or RT #1					C	olor RT #3 Color RT	#3				
Colo	or RT #0						Color RT #3		Color RT #0	Color RT #3		Color RT #9
Depth												
								-H DT 40	_			
						D	Dep Depth RT #0 Depth F	рtn кт #0 RT #0				
						De	epth RT #0 Depth R	RT #0				
						De	epth RT #0 Depth RT	#0				
						De	epth RT #0 Depth RT	#0				
P	H DT #0		Death DT #1	Death DT #1			Depth RT #0	th DT #0	Durth DT #0			Darth DT #0
Dep	UIKI#Ü		Depur RT #1	Depth RT #1			Dep	UI KT #U	Depth R1 #0			Depth R1 #0
Other												
			197									
+		47	Compute	+++++++++++++++++++++++++++++++++++++++	+ +++++++++++++++++++++++++++++++++++++	►4 ++ <del>  </del> ++			. t	t.	t t	
	42	Compute	Clear	Clear			-614	1	623	631 634	659	
<												>
Expar	nd tree V Group by tar	rget 🛛 🗸 Sele	ect columns								Search	Q
	Name Fo	ormat	Width	Height	Draw calls	Compression	Sample count	Out of order draw calls	Duration			
>	Color RT #0 VK	CFURMAT_R16G16B16A16_SFLOAT	1920	1080	33	ON	1	0/33	680.296 µs			
>	Color RT #1 VK	CFURMAT_R16G16B16A16_SFLOAT	1920	1080	30	ON	1	0/30	365.//2 µs			
>	Color RT #2 VK	CFORMAT_R16G16_SFLOAT	1920	1080	30	ON	1	0/30	365./72 μs			
>	Depth RT #0 VK	LEVENAT_D32_SFLOAT_S8_UINT	1920	1080	52	ON	1	0 / 52	3,66/.100 µs			
>	Depth RT #1 VK	LEVENAT_D32_SFLOAT	512	512	406	ON	1	406 / 406 (100.0%)	/11.623 µs			
>	Color RT #3 VK	C_FURMAT_R16G16B16A16_SFLOAT	1920	1080	13	ON	1	0 / 13	2,140.486 µs			
>	Color RT #4 VK	C_FORMAT_R16G16B16A16_SFLOAT	960	540	2	OFF	1	0/2	77.042 µs			
>	Color RT #5 VK	C_FURMAT_R16G16B16A16_SFLOAT	480	270	1	OFF	1	0/1	17.560 µs			
>	Color RT #6 VK	LEVENAT_R16G16B16A16_SFLOAT	480	270	1	ON	1	0/1	9.043 µs			
>	Color RT #7 VK	C_FURMAT_R16G16B16A16_SFLOAT	480	270	1	ON	1	0/1	7.634 µs			
>	Color RT #8 Vk	CFORMAT_R16G16B16A16_SFLOAT	1920	1080	1	OFF	1	0/1	65.890 µs			
>	Color RT #9 VK	_FORMAT_R8G8B8A8_UNORM	1920	1080	1	OFF	1	0/1	164.295 µs			

Understand all your render targets



- Three sections color, depth, other
- Displays when gfx/compute passes begin/end
- Hooked up to other RGP panes via context menu



- Three sections color, depth, other
- Displays when gfx/compute passes begin/end
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- Three sections color, depth, other
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- Three sections color, depth, other
- Displays when gfx/compute passes begin/end
- Hooked up to other RGP panes via context menu

	Expand	tree 🛛 🗸 Group by	r target	Select columns							
		Name	Format		Width	Height	Draw calls	Compression	Sample count	Out of order draw calls	Duration
>		Color RT #0	VK_FORMAT_R16G16B16A16_	SFLOAT	1920	1080	33	ON	1	0 / 33	680.296 µs
>		Color RT #1	VK_FORMAT_R16G16B16A16_	_SFLOAT	1920	1080	30	ON	1	0 / 30	365.772 µs
>		Color RT #2	VK_FORMAT_R16G16_SFLOAT	Г	1920	1080	30	ON	1	0 / 30	365.772 μs
>		Depth RT #0	VK_FORMAT_D32_SFLOAT_S8	3_UINT	1920	1080	52	ON	1	0 / 52	3,667.100 µs
>		Depth RT #1	VK_FORMAT_D32_SFLOAT		512	512	406	ON	1	406 / 406 (100.0%)	711.623 µs
>		Color RT #3	VK_FORMAT_R16G16B16A16_	SFLOAT	1920	1080	13	ON	1	0 / 13	2,140.486 µs
>		Color RT #4	VK_FORMAT_R16G16B16A16_	_SFLOAT	960	540	2	OFF	1	0 / 2	77.042 µs
>		Color RT #5	VK_FORMAT_R16G16B16A16_	_SFLOAT	480	270	1	OFF	1	0 / 1	17.560 µs
>		Color RT #6	VK_FORMAT_R16G16B16A16_	_SFLOAT	480	270	1	ON	1	0/1	9.043 µs
>		Color RT #7	VK_FORMAT_R16G16B16A16_	SFLOAT	480	270	1	ON	1	0 / 1	7.634 µs
>		Color RT #8	VK_FORMAT_R16G16B16A16_	SFLOAT	1920	1080	1	OFF	1	0 / 1	65.890 µs
>		Color RT #9	VK_FORMAT_R8G8B8A8_UNO	RM	1920	1080	1	OFF	1	0/1	164.295 µs

#### **Properties table**

- Dimensions and format
- Draw and sample counts
- Duration
- Optimizations

# RGP 1.4 - OpenCL<sup>™</sup> support



#### What is it?

RGP minus the graphics-only stuff

#### How do I use it?

- Developer panel now detects OpenCL<sup>™</sup> applications
- Set number of kernels, and capture!

# Planned for RGP 1.5.x

#### **Instruction timing**

Wavefront occupancy	Event timing	9	Pipeline	state	Instruction timing					
Vertex Shader	V Event: 455	[						Zoom to selection	Reset zoom	0 0
		Hit count	Avg duration (clk)	Duration pct	0 dk 187 dk	375 dk	562 clk 750	) clk 937	dk	1,1 ^
<pre>s_getpc_b64, s[0:1] s_mov_b32, s8, s5 </pre>		1	4 4	0.35						
<pre>s_mov_B32, 89, 81 s_load_dwordx4, s[8:11], v_add_u32_e32, v0, s6, v1</pre>	s[8:9], 0x0 0	1	4 8	0.35	1					
<pre>s_lshl_b32, s0, s2, 4 s_lshl4_add_u32, s3, s2, s_lshl4_add_u32, s5, s2,</pre>	16 32	1 1 1	4 4 4	0.35 0.35 0.35	1					
<pre>s_waitcnt, lgkmcnt(0) tbuffer_load_format_xyz,</pre>	v[0:3], v0, s[8:11]	1	168 8	14.69						
<pre>s_mov_b32, s6, s4 s_mov_b32, s7, s1 s load dwordx4, s[8:11],</pre>	s[6:7], 0x10	1 1 1	4 4 4	0.35 0.35 0.35						
<pre>s_waitcnt, lgkmcnt(0) s_buffer_load_dwordx4, s </pre>	[12:15], s[8:11], s0	1	40 4	3.50	•					
<pre>s_buffer_load_dwordx4, s s_buffer_load_dwordx4, s s_lshl4_add_u32, s0, s2,</pre>	[16:19], s[8:11], s3 [4:7], s[8:11], s5 48	1	4 4 4	0.35						
<pre>s_buffer_load_dwordx4, s s_waitcnt, vmcnt(0) v_mul_f32_e32_v3_s12_v</pre>	[0:3], s[8:11], s0	1 1	4 664 4	0.35 58.04 0.35						
v_mul_f32_e32, v4, s13, v_mul_f32_e32, v5, s14, v	v0 v0	1	4	0.35						
<pre>v_mul_f32_e32, v0, s15, v v_fma_f32, v3, s16, v1, v v fma_f32, v4, s17, v1, v</pre>	v0 v3 v4	1 1 1	4 4 4	0.35 0.35 0.35				1	I	
v_fma_f32, v5, s18, v1, v v_fma_f32, v0, s19, v1, v	75 70	1	4	0.35						
v_ima_i32, v1, s4, v2, v3 v_fma_f32, v3, s5, v2, v4 v_fma_f32, v4, s6, v2, v3	5 1 5	1	4 4 4	0.35					1	
v_fma_f32, v0, s7, v2, v0 v_add_f32_e32, v1, s0, v v_add_f32_e32, v2, s1, v	) 1 3	1 1 1	4 4 4	0.35 0.35 0.35						
v_add_f32_e32, v3, s2, v4 v_add_f32_e32, v0, s3, v6	- 4 D	1	4	0.35						
<pre>exp, pos0, v2, v3, v0 exp, param0, off, off, o s endpgm</pre>	ff	1 1 1	4 120 4	0.35 10.49 0.35						

#### **Shader ISA**



#### **User marker display**



Wavefront occupancy	Event timing	vent timing Pipeline state		Instruction timing						
Vertex Shader	Event: 455							Zoom to selection	Reset zoom	•
		Hit count	Avg duration (clk)	Duration pct	0 clk 187 dk	375 dk	562 dk 75	50 dk 937	dk	1,1 ^
s_getpc_b64, s[0:1] s_mov_b32, s8, s5		1	4	0.35 0.35	1					
<pre>s_mov_b32, s9, s1 s_load_dwordx4, s[8:11], s u add u22 a22 u0 s6 u0</pre>	[8:9], OxO	1 1	4	0.35	Υ.					
<pre>s_add_u32_e32, V0, s0, V0 s_lshl_b32, s0, s2, 4 s_lshl4_add_u32, s3, s2, 1</pre>	.6	1	4	0.35	1					
<pre>s_lshl4_add_u32, s5, s2, 3 s_waitcnt, lgkmcnt(0) </pre>	12	1	4 168	0.35						
s_mov_b32, s6, s4 s_mov_b32, s7, s1	/[0:3], VU, S[8:11].	1	4	0.35	1					
<pre>s_load_dwordx4, s[8:11], s s_waitent, lgkment(0)</pre>	[6:7], 0x10	1	4 40	0.35 3.50	L					
<pre>s_buffer_load_dwordx4, s[] s_buffer_load_dwordx4, s[] s_buffer_load_dwordx4, s[4]</pre>	l2:15], s[8:11], s0 l6:19], s[8:11], s3 l:7], s[8:11], s5	1 1 1	4 4 4	0.35 0.35						
<pre>s_lshl4_add_u32, s0, s2, 4 s_buffer_load_dwordx4, s[0 s_uaitent_ument(0)</pre>	8 ):3], s[8:11], s0	1 1	4 4 664	0.35	L 1					
v_mul_f32_e32, v3, s12, v0 v_mul_f32_e32, v4, s13, v0		1 1	4	0.35	-					
v_mul_f32_e32, v5, s14, v0 v_mul_f32_e32, v0, s15, v0		1 1	4	0.35					L	
v_fma_f32, v5, s10, v1, v5 v_fma_f32, v4, s17, v1, v4 v_fma_f32, v5, s18, v1, v5		1	4 4	0.35						
v_fma_f32, v0, s19, v1, v0 v_fma_f32, v1, s4, v2, v3		1	8	0.70					۱. I	
v_ima_132, v3, s3, v2, v4 v_fma_f32, v4, s6, v2, v5 v_fma_f32, v0, s7, v2, v0		1	4 4 4	0.35					1	
v_add_f32_e32, v1, s0, v1 v_add_f32_e32, v2, s1, v3 v_add_f32_e32, v3	-	1 1	4 4 4	0.35 0.35 0.35					1	
v_add_f32_e32, v3, s2, v4 v_add_f32_e32, v0, s3, v0 exp, pos0, v2, v3, v0		1 1	4	0.35					1	
<pre>exp, param0, off, off, off s_endpgm</pre>		1 1	120 4	10.49 0.35						$\sim$

- Top-down program execution
- Find which part of your program is hot
- Available for all shader stages

- See instruction durations
- Functional unit utilization (VALU, SALU, LDS)

Wavefront occupancy	Event timing	J	Pipeline	tate	Instruction timing					
Vertex Shader	V Event: 455							Zoon	n to selection Reset zoo	m 🖸 🗢
					0 clk 187 clk	375 clk	562 clk	750 clk	937 dk	1,1 ^
		HIT COUNT	Avg duration (CIK)	Duration pct	hummutuumuhuuuntu	muuluumuti	muuluuuutu	muluumt	muuluumutuu	umbi -
S Jecpe D04, S[U:1]		1	4	0.35						
s_mov_b32, s8, s5		1	4	0.35	1					
s_mov_b32, s9, s1		1	4	0.35	l i i i i i i i i i i i i i i i i i i i					
<pre>s_load_dwordx4, s[8:11],</pre>	s[8:9], 0x0	1	4	0.35	l l					
v_add_u32_e32, v0, s6, v0	0	1	8	0.70						
s_lsh1_b32, s0, s2, 4	16	1	4	0.35	- L					
$s_{15n14} add_{u32}, s3, s2,$	70	1	4	0.35	1.5					
s_isni4_add_usz, S3, S2,	32	1	168	14 69						
thuffer load format yvz	v[0:3], v0, s[8:11]	1	8	0.70						
s mov b32, s6, s4		1	4	0.35	1					
s mov b32, s7, s1		1	4	0.35	i i					
s load dwordx4, s[8:11],	s[6:7], 0x10	1	4	0.35	) (j					
s_waitcnt, lgkmcnt(0)		1	40	3.50						
<pre>s_buffer_load_dwordx4, s</pre>	[12:15], s[8:11], s0	1	4	0.35						
<pre>s_buffer_load_dwordx4, s</pre>	[16:19], s[8:11], s3	1	4	0.35						
<pre>s_buffer_load_dwordx4, s</pre>	[4:7], s[8:11], s5	1	4	0.35	l l					
<pre>s_lshl4_add_u32, s0, s2,</pre>	48	1	4	0.35	l					
<pre>s_buffer_load_dwordx4, s</pre>	[0:3], s[8:11], s0	1	4	0.35	L L					
<pre>s_waitcnt, vmcnt(0)</pre>		1	664	58.04						
v_mul_f32_e32, v3, s12, v	v0	1	4	0.35						
v_mul_f32_e32, v4, s13, v	0	1	4	0.35						
v_mul_I32_e32, V3, S14, V	0	1	4	0.35						
v_mu1_132_e32, V0, 813, V		1	4	0.35						
v_ima_132, v3, s10, v1, v	r4	1	4	0.35						
v fma f32 v5 s18 v1 v	v 5	1	4	0.35					- 1	
v fma f32. v0. s19. v1. v	70	1	8	0.70					1 N N	
v fma f32, v1, s4, v2, v3	3	1	4	0.35					- 1	
v fma f32, v3, s5, v2, v4	4	1	4	0.35					1	
v_fma_f32, v4, s6, v2, v5	5	1	4	0.35					i i	
v_fma_f32, v0, s7, v2, v0	D	1	4	0.35					Ì	
v_add_f32_e32, v1, s0, v1	1	1	4	0.35					1	
v_add_f32_e32, v2, <b>s1</b> , v3	3	1	4	0.35						
v_add_f32_e32, v3, <b>s2</b> , v4	4	1	4	0.35					l l l	
v_add_f32_e32, v0, s3, v0	0	1	4	0.35					ļ.	
exp, pos0, v2, v3, v0		1	4	0.35						
exp, param0, off, off, o:	ff	1	120	10.49						
sendpgm		1	4	0.35						$\sim$

- Top-down program execution
- Find which part of your program is hot
- Available for all shader stages

- See instruction durations
- Functional unit utilization (VALU, SALU, LDS)

Wavefront occupancy	Event timing	Pipeline state	Instruction timing			
Vertex Shader	Event: 455				Zoom to selection	Reset zoom 🛛 🔿 👄
			0 clk 187 clk	375 clk 562 clk	k 750 dk 937 dk	k 1,1 ^
	Hit count	Avg duration (dk) Duration pd				
s getpc b64, s[0:1]	1	4 0.35				
s mov b32, s8, s5	1	4 0.35	i i			
s_mov_b32, s9, s1	1	4 0.35	l)			
<pre>s_load_dwordx4, s[8:11], s</pre>	[8:9], 0x0 1	4 0.35				
v_add_u32_e32, v0, <b>s6</b> , v0	1	8 0.70				
s_lshl_b32, s0, s2, <b>4</b>	1	4 0.35	L .			
<pre>s_lshl4_add_u32, s3, s2, 1</pre>	1	4 0.35	l l			
s_lshl4_add_u32, s5, s2, 3	1	4 0.35				
<pre>s_waitent, lgkment(0)</pre>	1	168 14.69				
tbuffer_load_format_xyz, v	7[0:3], v0, s[8:11 1	8 0.70	L			
s_mov_b32, s6, s4	1	4 0.35				
s_mov_D32, s/, si	16.71 0-10	4 0.35	L 1			
s_road_dwordx4, s[8.11], s	1	40 3.50				
s buffer load dwordv4 s[1	12.151 st8.111 st 1	4 0.35				
s buffer load dwordx4, s[1	16:191. s[8:11], si 1	4 0.35	• · · · · · · · · · · · · · · · · · · ·			
s buffer load dwordx4. s[4	4:71. s[8:11]. s5 1	4 0.35	1			
s lsh14 add u32, s0, s2, 4	18 1	4 0.35	1			
s buffer load dwordx4, s[0	):3], s[8:11], s0 1	4 0.35	)			
s_waitcnt, vmcnt(0)	1	664 58.04				
v_mul_f32_e32, v3, s12, v0	1	4 0.35				
v_mul_f32_e32, v4, s13, v0	1	4 0.35				
v_mul_f32_e32, v5, <b>s14</b> , v0	1	4 0.35			Į	
v_mul_f32_e32, v0, s15, v0	1	4 0.35			l l	
v_fma_f32, v3, <b>s16</b> , v1, v3	1	4 0.35			l l	
v_fma_f32, v4, s17, v1, v4	1	4 0.35			l l l l l l l l l l l l l l l l l l l	
v_fma_f32, v5, s18, v1, v5	1	4 0.35			L. L.	
v_fma_f32, v0, s19, v1, v0		8 0.70				
v_ima_i32, v1, s4, v2, v3	1	4 0.35				
v_ima_i32, v3, s5, v2, v4	1	4 0.35				
v_ima_i32, v4, s6, v2, v5	1	4 0.35				
v_ima_132, v0, s7, v2, v0	1	4 0.35				
v_add_f32_e32_v2_e1_v2	1	4 0.35				
v add f32 e32, v2, s1, v3	1	4 0.35				
v add f32 e32, v0, s3, v0	1	4 0.35				1 I I
exp, pos0, v2, v3, v0	1	4 0.35				1
exp, param0, off, off, off	e 🚺	120 10.49				
s_endpgm	1	4 0.35				$\sim$

- Top-down program execution
- Find which part of your program is hot
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- See instruction durations
- Functional unit utilization (VALU, SALU, LDS)

wavenone occupancy Event timing Pipeline state Instruction timing				
Vertex Shader VEvent: 455	om to selection	Reset zoom	0	0
Hit count Avg duration (dk) Duration pct	937 c	ак	1,1	^
s getpc b64, s[0:1] 1 4 0.35				
s mov b32, s8, s5 1 4 0.35				
s mov b32, s9, s1 1 4 0.35				
s load dwordx4, s[8:11], s[8:9], 0x0 1 4 0.35				
v add u32 e32, v0, s6, v0 1 8 0.70				
s lshl b32, s0, s2, 4 1 4 0.35				
s lshl4 add u32, s3, s2, 16 1 4 0.35				
s lshl4 add u32, s5, s2, 32 1 4 0.35				
s waitcnt, 1gkmcnt(0) 1 168 14.69				
tbuffer load format xyz, v[0:3], v0, s[8:11]1 8 0.70				
s mov b32, s6, s4 1 4 0.35				
s mov b32, s7, s1 1 4 0.35				
s load dwordx4, s[8:11], s[6:7], 0x10 1 4 0.35				
s waitent, lgkment(0) 1 40 3.50				
s buffer load dwordx4, s[12:15], s[8:11], s0 1 4 0.35				
s buffer load dwordx4, s[16:19], s[8:11], s31 4 0.35				
s buffer load dwordx4, s[4:7], s[8:11], s5 1 4 0.35				
s lshl4 add u32, s0, s2, 48 1 4 0.35				
s buffer load dwordx4, s[0:3], s[8:11], s0 1 4 0.35				
s waitent, vment(0) 1 664 58.04				
v mul f32 e32, v3, s12, v0 1 4 0.35				
v mul f32 e32, v4, s13, v0 1 4 0.35	ì			
v mul f32 e32, v5, s14, v0 1 4 0.35	) i			
v mul f32 e32, v0, s15, v0 1 4 0.35				
v fma f32, v3, s16, v1, v3 1 4 0.35				
v fma f32, v4, s17, v1, v4 1 4 0.35				
v fma f32, v5, s18, v1, v5 1 4 0.35				
v fma f32, v0, s19, v1, v0 1 8 0.70				
v fma f32, v1, s4, v2, v3 1 4 0.35		1		
v fma f32, v3, s5, v2, v4 1 4 0.35		1		
v fma f32, v4, s6, v2, v5 1 4 0.35		1		
v fma f32, v0, s7, v2, v0 1 4 0.35		-1		
v add f32 e32, v1, s0, v1 1 4 0.35		-1		
v add f32 e32, v2, s1 v3 1 4 0.35		- 1		
y add f32 e32, y3, s2, y4 1 4 0.35		- 1		
v add f32 e32, v0, s3, v0 1 4 0.35		- 1		
		- Y		
exp. param0. off off off 1 120 10.49				
s endorm 1 4 0.35				

- Top-down program execution
- Find which part of your program is hot
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- See instruction durations
- Functional unit utilization (VALU, SALU, LDS)
### Planned for RGP 1.5.x - Shader ISA



See shader code in pipeline state

# Planned for RGP 1.5.x - User marker display



#### Know what the GPU is working on

# Planned for RGP 1.5.x - User marker display



#### Know what the GPU is working on

### AGENDA

### Microsoft<sup>®</sup> PIX for Windows Rodrigo Urra

### Introduction

### AMD-specific GPU data

# What is Microsoft<sup>®</sup> PIX for Windows?

### Graphics debugging and perf tuning tool

DirectX<sup>®</sup> 12 on Windows 10

<b></b>							miniengine_a	april2017.pix3 - PIX on	Windows							?	₽ <b>- ¤ ×</b>
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Overview	Pipeline	lools Debug												Analysis is running.	Local mat	hine (locainost) 👻 📕 Radeon ita veg	ga 👻 🗤 🖓 🖓
Events														Screen Shot	File Details	A Warnings (3) Outpu	rt
< > G	raphics Queue 0	J (CommandListManager::m_CommandQueue)	▼ .* Aa !G	Filter (Ctrl+E)			1				_		t Timing Data   📓		1 And	( A A A A	N Ball
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360		DrawIndexedInstanced(96,1,692112,0,0)	) {this->I	110	0	0	27,744	640	72		A Cou	etault 🕯 (*)	•	44			and the second second
363		DrawIndexedInstanced(52788,1,692208,6	0,0) {this	118	0	9	827,968	26,497	13,969		- Filte	Iter		VALL			
365		DrawIndexedInstanced(6696,1,744996,0,	,0) (this-	119	0	0	103,360	2,156	1,692		Aa .	. Filter (Ctrl+E)	× •	- let		1. 1	
308		Drawindexedinstanced(4800,1,751092,0) DrawindexedInstanced(27552.1,756492.0)	0.0) {this	120	0	9	629,696	9,893	2,035		- Cou	TOP to EOP Dupotion (er)	0	31/1	- The		
374		DrawIndexedInstanced(9126,1,784044,0	,0) {this-	122	0	0	202,752	3,281	2,496			AMD: ColorBuffer	2 selected				
377		DrawIndexedInstanced(43452,1,793170,0	0,0) {this	123	0	9	2,651,648	4,343,124	340,342		[	CBColorAndMaskRead		CALL I		Second Constants of the second	
380	4 <	<pre>(deprecated - use pix3.h instead&gt; Render Recourse Render(2) ) (this &gt;ID201)</pre>	er Color	124-158	8,411,488	8,411,488	24,335,648	13,051,739	919,645		ľ	CBMemRead		Charles -			300
387		DrawIndexedInstanced(54582,1,0,0,0)	{this->ID3	124	0	0	989,120	50,645	15,731		la l	CBMemWritten     CBSlowPixelCount		COL			and the
392		DrawIndexedInstanced(5616,1,54582,0,6	0) {this->	126	30,624	30,624	317,280	104,347	7,215			AMD: ComputeShader		Color and		the state of the s	A start
395		DrawIndexedInstanced(53064,1,60198,0,	,0) {this-	127	83,040	83,040	1,109,024	283,204	24,084		2.4	AMD: DepthAndStencil					
398		DrawIndexedInstanced(12258,1,113262,6	0,0) {this	128	542,240	542,240	816,640	665,313	25,718			AMD: GeometrySnader AMD: GlobalMemory	6 selected				
401		Drawindexedinstanced(50688,1,125520,0 DrawindexedInstanced(870,1,176208,0,0	0,0) {this->	129	135.744	135.744	581,216	40,287	13,256		) + I	AMD: HullShader					
406		DrawIndexedInstanced(1518,1,177078,0.	,0) {this-	131	3,043,040	3,043,040	3,431,616	3,790,288	228,053		**	AMD: PixelShader					
409		DrawIndexedInstanced(7368,1,178596,0,	,0) {this-	132	0	9	186,240	9,602	3,006			AMD: TextureUnit					
412		DrawIndexedInstanced(17628,1,185964,6	0,0) {this	133	575,424	575,424	998,848	366,123	27,752		14	AMD: Timing					
415		DrawIndexedInstanced(8448,1,203592,0, DrawIndexedInstanced(23136.1,212040.0	,0) (this	134	938,016	938,016	1,813,568	1,188,494	11.840			AMD: VertexSnader D3D: Depth Occlusion					
421		DrawIndexedInstanced(48,1,235176,0,0)	) {this->I	136	0	0	1,728	45	15		- F F	D3D: Pipeline Statistics					
424		DrawIndexedInstanced(21264,1,235224,0	0,0) {this	137	93,024	93,024	999,168	172,566	17,260		• •	D3D: Stream Output Statistics					
427		DrawIndexedInstanced(2640,1,256488,0,	,0) {this-	138	0	9	63,488	3,233	1,025								
430		DrawIndexedInstanced(15,1,259128,0,0) DrawIndexedInstanced(56445,1,259143,0	) {this->1 0.0) {this	139	2,069,024	2,069,024	2,538,976	4,355,959	223,388								
435		DrawIndexedInstanced(12312,1,315588,6	0,0) {this	140	0	0	281,792	14,393	4,565								
438		DrawIndexedInstanced(54,1,327900,0,0)	) {this->I	142	0	9	2,816	103	32	-							
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- 0000000																Shader Wait/Stall	
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VS DS	HS	· · · · · · · · · · · · · · · · · · ·	1 1 1 1					. <b>.</b>								AMD: DepthAndStencil	
PS	CS															AMD: GeometryShader	1
incentar		0	L		1. A A A A A A A A A A A A A A A A A A A		نال النان									AMD: GlobalMemory     FetchSize	4 selected
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		110,924.00									_				$\sim$	L2CacheMissCount	
															(m)	WriteSize	
ount														F		AMD: PixelShader	
Hito		84 322 09						1					_			AMD: PrimitiveAssembly	
ache								- A	~		_					AMD: TextureUnit     AMD: Timing	
120								~ 1						-	Lit	AMD: VertexShader	
								1				/				Count of fetch, write, atomic and oth	ver instructions
		71,206.00														that hit the L2 cache.	
		🕱 — Fetc'	hSize 🗶 —	L1CacheMissCo	Junt 🗶 — L2CacheHitCourr	🗙 — WriteSize	1										

# What is Microsoft<sup>®</sup> PIX for Windows?

### Graphics debugging and perf tuning tool

DirectX<sup>®</sup> 12 on Windows 10

<b></b>						miniengine_	april2017.pix3 - PIX on	Windows					?	₽ - ¤ ×
Home	Loca	al Machine × iminiengine_april2017.pix3 ×											1004	
Overview	Pipeline	Tools Debug									Analysis is <b>running</b> .	Local Machi	iine (localhost) 💌 Radeon RX Vi	293 ¥ 🗖 🛱
Lvent	5										Screen Shot	File Details	▲ Warnings (3) Outp	ut
< >	Graphics Queue	e 0 (CommandListManager::m_CommandQueue) 👻 ,* 🗛	IG Filter (Ctrl							🗙 🕶 🗠 💟 🗈 Collect Timing Data   👔	A MAY	"ASA	ATA	
Queue II	) Name	Designation of a second state of a line of the second state of the	Global ID	CBColorAndMaskWritten	CBMemWritten	FetchSize	L1CacheHitCount	L1CacheMissCount	L2Cac *	Counters	SUCT.	A DECK	A	
3	50	DrawIndexedInstanced(96,1,692112,0,0) {this->	I 117	0	0	27,744	640	72		Counter Sets     Default ■ (*)     ✓	No.			Statement of the local division of the local
3	53	DrawIndexedInstanced(52788,1,692208,0,0) {thi	s 118	0	0	827,968	26,497	13,969		<ul> <li>Filter</li> </ul>	N/14			
3	5 68	DrawIndexedInstanced(6696,1,744996,0,0) {this DrawIndexedInstanced(4890,1,751692,0,0) {this	- 119	0	0	103,360	2,156	1,692		Aa .* Filter (Ctri+E) X •	- Alt	1 the start		
3	71	DrawIndexedInstanced(27552,1,756492,0,0) {thi	s 121	0	9	629,696	9,194	7,101		TOP to EOP Duration (ns)		18 - 18 to 2	10 A	
3	74	DrawIndexedInstanced(9126,1,784044,0,0) {this	- 122	0	0	202,752	3,281	2,496		AMD: ColorBuffer 2 selected      CRColorBuffeskRead	CALE.			1.50
3	80 4	<pre><deprecated -="" instead="" pix3.h="" use=""> Render Color</deprecated></pre>	124-158	8,411,488	8,411,488	24,335,648	13,051,739	919,645		CBColorAndMaskWritten	ALT LOW	1		
3:	37	ResourceBarrier(3,) {this->ID3D12GraphicsC	0 124	0	0	θ	0	0		CBMenNead CBMenNritten	ASP.			the Alt
3:	39 92	DrawIndexedInstanced(54582,1,0,0,0) {this->ID DrawIndexedInstanced(5616,1,54582,0,0) {this-	3 125 > 126	0 30.624	30.624	989,120	50,645	15,731		CBS1owPixe1Count AMD: ComputeShader	the second		- the second	the second
3	95	DrawIndexedInstanced(53064,1,60198,0,0) {this	- 127	83,040	83,040	1,109,024	283,204	24,084		AMD: DepthAndStencil				
3	98	DrawIndexedInstanced(12258,1,113262,0,0) {thi	s 128	542,240	542,240	816,640	665,313	25,718		AMD: GeometryShader     AMD: GlobalMemory 6 selected				
4	34	DrawIndexedInstanced(50688,1,125520,0,0) {this- DrawIndexedInstanced(870,1,176208,0,0) {this-	s 129 > 130	135,744	135,744	581,216	40,287	13,256		AMD: HullShader				
4	96	DrawIndexedInstanced(1518,1,177078,0,0) {this	- 131	3,043,040	3,043,040	3,431,616	3,790,288	228,053		AMD: PixelShader     AMD: PrimitiveAssembly				
4	39 12	DrawIndexedInstanced(7368,1,178596,0,0) {this DrawIndexedInstanced(17628,1,185964,0,0) {this	- 132 s 133	0 575-424	0 575.424	186,240	9,602	3,006		AMD: TextureUnit     AMD: Timing				
4	15	DrawIndexedInstanced(8448,1,203592,0,0) {this	- 134	938,016	938,016	1,813,568	1,188,494	79,544		AMD: VertexShader				
4	18	DrawIndexedInstanced(23136,1,212040,0,0) {thi	s 135	190,784	190,784	682,592	85,298	11,840		D3D: Depth Occlusion     D3D: Binaline Statistics				
4.	24	DrawIndexedInstanced(48,1,235176,0,0) {this-> DrawIndexedInstanced(21264,1,235224,0,0) {thi	I 136 S 137	93,024	93,024	1,728	45	17,260		D3D: Stream Output Statistics				
4:	27	DrawIndexedInstanced(2640,1,256488,0,0) {this	- 138	0	9	63,488	3,233	1,025						
4	30	DrawIndexedInstanced(15,1,259128,0,0) {this-> DrawIndexedInstanced(56445 1 259142,0,0) {this	1 139	2,069,024	2,069,024	2,538,976	4,355,959	223,388						
4	35	DrawIndexedInstanced(12312,1,315588,0,0) {thi	s 1	0	0	281,792	14,393	4,565						
4	38	DrawIndexedInstanced(54,1,327900,0,0) {this->	I .42	0	9	2,816	103	32	-		1020+1057			
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🗘 Set	tings	0.0000 ms     0.0 ms     0.1 ms	0.2 ms	0.3 ms 0.4 ms	0.5 ms 0.6 m	1s 0.7 ms	0.8 ms 0.9 m	ns / 1.88 ms ns 1.0 ms	1.1 ms	1.2 ms 1.2760 ms 1.4 ms 1.5 ms	1.6 ms 1.7 ms	1.8783 ms 1.8 ms	Counters	$\bigtriangledown$ X
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Card	Comments	V-0.2%/2		- <u>-</u>	N				<u> </u>				Aa Filter (Ctrl+E)	× •
Copy	Compute												Global Instructions	-
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ount							1				Л		AMD: PixelShader	
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		71,206.00				7						ı	over the the L2 cache.	
		X - FetchSize	L1CacheMissCo	unt [[X] — L2CacheHitCour	t WriteSize	:								

# What is Microsoft<sup>®</sup> PIX for Windows?

Graphics debugging and perf tuning tool

DirectX<sup>®</sup> 12 on Windows 10

<b></b>								miniengine_i	april2017.pix3 - PIX on	Windows						?	9 - O ×
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Overview	Pipeline	Tools	Debug											Analysis is <b>running</b> .	Local Ma	chine (localhost) 💌 🛛 Radeon RX Veç	ga 👻 🔽 🖓
Events														Screen Shot	File Details	A Warnings (3) Outpu	ıt
< > G	aphics Queue	0 (CommandList	:Manager::m_Comma	andQueue) 👻 🔭 🗛 🛙 G	Filter (Ctrl+E)							X 🗸 🔨 🗈 Collect Timing I	Data   💼	100 1001 00 00 000 000 00 10		E ATT IN	
Queue ID	Name				Global ID	CBColorAndMaskWritten	CBMemWritten	FetchSize	L1CacheHitCount	L1CacheMissCount	L2Cac *	Counters	⊽ X	A A	A		
357		DrawIndexedI	Instanced(43008,1	1,649104,0,0) {this	116	0	0	734,720	101,208	14,176		Counter Sets		SV CT		47. A	
360		DrawIndexedI DrawIndexedI	Instanced(96,1,69 Instanced(52788.1	92112,0,0) {this->I 1.692208.0.0) {this	117	0	0	27,744	640 26,497	72		Default @ (*)	• 🗸		In the second second		Marken Mr.
365		DrawIndexedI	Instanced(6696,1,	,744996,0,0) {this-	119	0	0	103,360	2,156	1,692		Aa .* Filter (Ctrl+E)	× •	- HIL			Research in
368		DrawIndexedI	Instanced(4800,1,	,751692,0,0) {this-	120	0	0	168,064	9,893	2,035		Counters	0	XILT			
371		DrawIndexedI	Instanced(27552,1 Instanced(9126,1,	,784044,0,0) {this-	121	0	0	202,752	3,281	2,496		<ul> <li>TOP to EOP Duration (ns)</li> <li>AMD: ColorBuffer</li> </ul>	2 selected				
377		DrawIndexedI	Instanced(43452,1	1,793170,0,0) {this	123	0	0	2,651,648	4,343,124	340,342		CBColorAndMaskRead		1 And And		Second Barries Barries	1
380	4	<deprecated -<="" td=""><td>use pix3.h inste</td><td>ead&gt; Render Color</td><td>124-158</td><td>8,411,488</td><td>8,411,488</td><td>24,335,648</td><td>13,051,739</td><td>919,645</td><td></td><td>CBMenRead</td><td></td><td>No. 15</td><td></td><td></td><td>No. No.</td></deprecated>	use pix3.h inste	ead> Render Color	124-158	8,411,488	8,411,488	24,335,648	13,051,739	919,645		CBMenRead		No. 15			No. No.
387		DrawIndexedI	Instanced(54582,1	1,0,0,0) {this->ID3	124	0	0	989,120	50,645	15,731		CBMemWritten     CBSlowPixelCount		COL.		and printing	and the
392		DrawIndexedI	Instanced(5616,1,	,54582,0,0) {this->	126	30,624	30,624	317,280	104,347	7,215		AMD: ComputeShader		all's all		and the state of t	- All Cart
395		DrawIndexedI	Instanced(53064,1	1,60198,0,0) {this-	127	83,040	83,040	1,109,024	283,204	24,084		AMD: DepthAndStencil     AMD: GeometryShader					
398		DrawIndexedI	Instanced(12258,1 Instanced(50688,1	1,113262,0,0) {this 1,125520,0,0) {this	128	542,240	542,240	816,640	665,313 40,287	25,718		AMD: GlobalMemory	6 selected				
404		DrawIndexedI	Instanced(870,1,1	176208,0,0) {this->	130	135,744	135,744	581,216	329,573	14,293		AMD: HullShader     AMD: RivelShader					
486		DrawIndexedI	Instanced(1518,1,	,177078,0,0) {this-	131	3,043,040	3,043,040	3,431,616	3,790,288	228,053		AMD: PrimitiveAssembly					
409		DrawIndexedI	Instanced(7368,1, Instanced(17628.1	,178596,0,0) {this 1.185964.0.0) (this	132	575.424	575,424	186,240	366,123	27,752		AMD: TextureUnit     AMD: Timing					
415		DrawIndexedI	Instanced(8448,1,	,203592,0,0) {this-	134	938,016	938,016	1,813,568	1,188,494	79,544		AMD: VertexShader					
418		DrawIndexedI	Instanced(23136,1	1,212040,0,0) {this	135	190,784	190,784	682,592	85,298	11,840		D3D: Depth Occlusion     D3D: Rineline Statistics					
421		DrawIndexedI	Instanced(48,1,23 Instanced(21264,1	35176,0,0) {this->I 1,235224,0,0) {this	136	93,024	93,024	1,728	45	15		D3D: Stream Output Statistics					
427		DrawIndexedI	Instanced(2640,1,	,256488,0,0) {this-	138	0	0	63,488	3,233	1,025							
430		DrawIndexedI	Instanced(15,1,25	59128,0,0) {this->I	139	2,069,024	2,069,024	2,538,976	4,355,959	223,388							
433		DrawIndexedI DrawIndexedI	Instanced(56445,1 Instanced(12312.1	1,259143,0,0) {this 1.315588.0.0) {this	140	0	0	1,137,536	56,958	17,840							
438		DrawIndexedI	Instanced(54,1,32	27900,0,0) {this->I	142	0	0	2,816	103	32							
											•			1920×1057			
Timelin																	
* Aa Filter	(Ctrl+E)																X - I M
- normer	(autria)		0.0	0000 ms	1	1 1	1 1	1	1.8783 m	ns / 1.88 ms	1		1	I I	1.8783 n	me .	
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<ul> <li>Execution I</li> </ul>	Duration															▲ Filter	
Granhics	Comnute		X		WQ -		N - 2	1991 - 1993			<u> </u>		< <u></u>			A Counters	
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	HS		10				1.1.1		- A 1							AMD: ComputeShader	
DS	GS								1- <b>6</b> 16							AMD: DepthAndStencil     AMD: GeometryShader	
Internal																AMD: GlobalMemory	4 selected
			0			1									× Smooth	<ul> <li>FetchSize</li> <li>LiCacheMissCount</li> </ul>	
			110,924.00												$\sim$	L2CacheHitCount	
			-									/		Xr	M	WriteSize	
ount									1					A		AMD: HullShader     AMD: PixelShader	
HitCo			84 333 00						1							AMD: PrimitiveAssembly	
achel			84,322.09						-t-	~						AMD: TextureUnit     AMD: Timing	
120									~~~			Lange 1 and		I	-h	AMD: VertexShader	
									1			//		J <sup>e</sup>		Count of fetch write atomic and oth	+
			71,206.00									/				that hit the L2 cache.	er mattuccions
			×	C — FetchSize 🗶 —	L1CacheMissO	ount 🗶 — L2CacheHitCour	t 🗙 — WriteSize	]									
			-														

# Microsoft<sup>®</sup> PIX for Windows – AMD support

Graphics debugging and perf tuning tool – DirectX<sup>®</sup> 12 on Windows 10

**AMD-specific GPU data** 

– Event list counters

٠				_					_	miniengine_a	pril2017.pix3 - PIX on	Windows				_		? [	2 – O ×
Home	Local	Machine X	1 <b>0</b> m	niniengine_april2	017.pix3 ×														
Overview	Pipeline	Tools	Debug												Analysis is <b>runr</b>	ning. O	Local Machir	ne (localhost) 💌 🛛 Radeon RX Veg	a • 🔽 🖾
Events															Screen Sh	iot File	e Details	A Warnings (3) Output	
< > Gra	phics Queue (	) (CommandLis	tManager::m (	CommandQueue)	▼ .* Aa !G	Filter (Ctrl+E)								X V Collect Timing Data		1512 141, 57 10	2574		600
Queue ID	Name					Global ID	CBCs AndMaskW	itten CBMen	Written Fe	tchSize	L1CacheHitCount	L1CacheMissCount	L2Cac *	Counters		the set	A-LARDA	A manage	N. State
357		DrawIndexed	Instanced(4	3008,1,649104,	0,0) (this	116		0	0	734,720	101,208	14,176		Counter Sets				1. 30 M .	
360		DrawIndexed	Instanced(9	6,1,692112,0,0	) {this->I	117		0	0	27,744	640	72		Default 🖨 (*)		12.20		1. 1. 1. 1.	A COLUMN TO
363		DrawIndexed	Instanced(5)	2788,1,692208,	0,0) {this	118		0	0	827,968	26,497	13,969		Filter		F	IT. THE		
368		DrawIndexed	Instanced(4	800,1,751692,0	0,0) (this-	120		0	0	168,064	9,893	2,035		Aa .* pitter (Ctri+E)					
371		DrawIndexed	Instanced(2	7552,1,756492,	0,0) {this	121		0	0	629,696	9,194	7,101		TOP to EOP Duration (ns)		11 may	and the get	14 - 14 - A - 1	
374		DrawIndexed	Instanced(9	126,1,784044,0	9,0) {this-	122		0	0	202,752	3,281	2,496		AMD: ColorBuffer 2 select	ted William		100 M		the last
377		DrawIndexed	Instanced(4	3452,1,793170,	0,0) (this	123	8 411	488 8	0	2,051,048	4,343,124	340,342		CBColorAndMaskkrad	S. P.L.		8 9		
387		ResourceBar	rier(3,)	{this->ID3D1	2GraphicsCo	124	0,41	0	0	0	0	0		CBMemRead	LA IN			70 000	124
389		DrawIndexed	Instanced(5	4582,1,0,0,0)	{this->ID3	125		0	0	989,120	50,645	15,731		CBSlowPixelCount	1.81		- Lagrand		
392		DrawIndexed	Instanced(5	616,1,54582,0,	0) {this->	126	36	,624	30,624	317,280	104,347	7,215		AMD: ComputeShader     AMD: DepthAndStepcil			V THE STATE	and and a state of the state of	and the second second second
395		DrawIndexed	Instanced(5)	2258.1.113262	0.0) {this	127	83	,040	65,840 542,240	816.649	283,204	24,084		AMD: GeometryShader					
401		DrawIndexed	Instanced(5	0688,1,125520,	0,0) (this	129	542	0	0	616,320	40,287	13,256		AMD: GlobalMemory 6 select	ted				
404		DrawIndexed	Instanced(8	70,1,176208,0,	0) {this->	130	135	,744	135,744	581,216	329,573	14,293		AMD: HullShader     AMD: PixelShader					
406		DrawIndexed	Instanced(1	518,1,177078,0	(this-	131	3,043	,040 3,	043,040	3,431,616	3,790,288	228,053		AMD: PrimitiveAssembly					
409		DrawIndexed	Instanced(7	368,1,178596,0	0.0) {this-	132	676	0	0 575.424	186,240	9,602	3,006		AMD: TextureUnit     AMD: TextureUnit					
412		DrawIndexed	Instanced(8	448,1,203592,0	0,0) {this-	134	938	,016	938,016	1,813,568	1,188,494	79,544		AMD: Iming     AMD: VertexShader					
418		DrawIndexed	Instanced(2	3136,1,212040,	0,0) {this	135	196	,784	190,784	682,592	85,298	11,840		D3D: Depth Occlusion					
421		DrawIndexed	Instanced(4	8,1,235176,0,0	) {this->I	136		0	0	1,728	45	15		D3D: Pipeline Statistics     D3D: Stream Output Statistics					
424		DrawIndexed	Instanced(2)	1264,1,235224,	0,0) {this	137	93	,024	93,824	63 499	1/2,566	17,260			-				
430		DrawIndexed	Instanced(1)	5,1,259128,0,0	) {this->I	139	2,069	,024 2,	069,024	2,538,976	4,355,959	223,388							
433		DrawIndexed	Instanced(5	6445,1,259143,	0,0) {this	140		0	0	1,137,536	56,958	17,840							
435		DrawIndexed	Instanced(1	2312,1,315588,	0,0) {this	141		0	0	281,792	14,393	4,565							
438		DrawIndexed	IInstanced(5	4,1,327900,0,0	) {tnis->1	142		0	0	2,816	103	32	-		1920×1057				
Timeline																			
•* Aa Filter (	Ctrl+E)																		× 🕶   💼
C Setting	s			0.0000 ms	0.1	[		0.6 mm	0.6 mm	0.7	1.8783	ms / 1.88 ms	l	12mm [12702.000]		7	1.8783 ms	Counters	⊽ X
Graphics Qu	eue 0 (Command	ListManager:m_C	CommandQueue)	EOP	U.I ms	0.2 ms	U.3 ms U.4 ms	0.5 ms	0.0 ms	u./ ms	0.8 ms 0.9 P	ns 1.0 ms	1.1 ms	1.2 ms 1.2700 ms 1.4 ms 1.5 ms	1.0 ms	1.7 ms	1.8 ms	▲ Counter Sets	
				8		5	atom to a					the part of the		i a se		· ·	_	Timeline Default 🌢 (*)	• 🗸
- Execution Du	ration																	Filter	
Granhier				A-00444	9 C.	<u> </u>		- 1 V -	- 19 A	- 12.			<u> </u>					Ala - Filter (Ctri+E)	^ •
Сору	Jinpore																	Global Instructions	-
<ul> <li>Occupancy</li> </ul>																		Shader Wait/Stall	
				10														AMD: ComputeShader	
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. counters			110.924	4.00													smootn	L1CacheMissCount	
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ŧ														N		41		AMD: HullShader	
Cour											1			A l		$\square$		AMD: PixelShader	
heHit			84,322	2.09							1					/   /		AMD: PrimitiveAssembly     AMD: TextureUnit	
Cach										~	~~~~	~						AMD: Timing	
2											}						$\Rightarrow$	AMD: VertexShader	
					-						1			/				Count of fetch, write, atomic, and othe	er instructions
			71,206	6.00													1	that hit the L2 cache.	
				🗙 — Feto	chSize 🗶 —	L1CacheMissCo	unt 🗶 — L2Cachel	itCount 🗶 —	WriteSize										
_																			

### Event list counters: Command-specific counters

CBColorAndMaskWritten	CBMemWritten	FetchSize	L1CacheHitCount	L1CacheMissCount	L2Cac 🕈	🛱 Counters	$\bigtriangledown$
0	0	734,720	101,208	14,176		<ul> <li>Counter Sets</li> </ul>	
0	0	27,744	640	72		Default 🚔 (*)	•
0	0	827,968	26,497	13,969		▲ Filter	
0	0	103,360	2,156	1,692		Aa .* Filter (Ctrl+E)	×
0	0	168,064	9,893	2,035		4 Counters	
0	0	629,696	9,194	7,101		TOP to EOP Duration (ns)	
0	0	202,752	3,281	2,496		✓ AMD: ColorBuffer	2 selected
0	0	2,651,648	4,343,124	340,342		CBColorAndMaskRead	
8,411,488	8,411,488	24,335,648	13,051,739	919,645		CBColorAndMaskWritten	
0	0	0	0	0		CBMemWritten	
0	0	989,120	50,645	15,731		CBSlowPixelCount	
30,624	30,624	317,280	104,347	7,215		AMD: ComputeShader	
83,040	83,040	1,109,024	283,204	24,084		AMD: DepthAndStencil	
542,240	542,240	816,640	665,313	25,718		AMD: GeometryShader	
0	0	616,320	40,287	13,256		AMD: GlobalMemory	6 selected
135,744	135,744	581,216	329,573	14,293		AMD: HullShader	
3,043,040	3,043,040	3,431,616	3,790,288	228,053		AMD: PixelShader	
0	0	186,240	9,602	3,006		AMD: PrimitiveAssembly	
575,424	575,424	998,848	366,123	27,752		AMD: Timing	
938,016	938,016	1,813,568	1,188,494	79,544		AMD: VertexShader	
190,784	190,784	682,592	85,298	11,840		D3D: Depth Occlusion	
0	0	1,728	45	15		D3D: Pipeline Statistics	
93,024	93,024	999,168	172,566	17,260		D3D: Stream Output Statistics	
0	0	63,488	3,233	1,025			
2,069,024	2,069,024	2,538,976	4,355,959	223,388			
0	0	1,137,536	56,958	17,840			
0	0	281,792	14,393	4,565			
0	0	2,816	103	32			
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# Microsoft<sup>®</sup> PIX for Windows – AMD support

Graphics debugging and perf tuning tool

DirectX<sup>®</sup> 12 on Windows 10

### AMD-specific GPU data

- Event list counters
- Wavefront occupancy (SQTT)

<b></b>									miniengine_	april2017.pix3 - PIX on	Windows						? ८	) – 🗆 ×
Home	📋 Local	Machine X	🖸 minie	engine_april	2017.pix3 ×													
Overview	Pipeline	Tools [	Debug										Ana	alysis is <b>runnin</b>	19. O	Local Mad	hine (localhost) 💌 🛛 Radeon RX Vega	- 🗆 🖂
Evente														Screen Shot		ila Dataile	A Warnings (3) Output	
	phice Output	) (CommandListMa	anaor:m Com	mandOuouo	0 <b>-</b>	C Dians (Carl ) D						X - A X El Callast Timing Data		Server Shot	11.0	ine Details	Varinings (5) Output	
	apriles Quede v	o (commandelstme	unuger.m_com	interrorectede	. Ma			CD11 11/14	F + 1 6	146 1 1996	146 L MR 6 4 106	A Contect mining bata				E-area	ALLAN	Sale /
Queue ID 357	Name	DrawIndexedIns	stanced(4300)	8.1.649104	.0.0) (thi	GIODAI ID	CBCOIOFAndiviaskwritten	Comemveritten	734.720	101, 208	14.176		~ ×					
360		DrawIndexedIns	stanced(96,1	,692112,0,1	0) {this->	117	0	0	27,744	640	72	Default  (*)			TP			The second s
363		DrawIndexedIns	stanced(5278	8,1,692208	,0,0) {thi	118	0	0	827,968	26,497	13,969	▲ Filter					THE REAL PROPERTY AND	
365		DrawIndexedIns	stanced(6696	,1,744996,	0,0) {this	119	0	0	103,360	2,156	1,692	Aa .* Filter (Ctrl+E)	× •	- Alt	hour		1. 1. 5 . 5 . 6	
368		DrawIndexedIns	stanced(4800	1,1,751692,0 2 1 756492	0,0) {this	120	0	0	168,064	9,893	2,835	Counters	0	24/h		TTO		
374		DrawIndexedIns	stanced(9126	,1,784044,	0,0) {this	122	0	0	202,752	3,281	2,496	AMD: ColorBuffer 2 se	icted			2		
377		DrawIndexedIns	stanced(4345)	2,1,793170	,0,0) {thi	123	0	0	2,651,648	4,343,124	340,342	CBColorAndMaskRead		(A)			See Berley Brown	1546
380		deprecated - u	se pix3.h in	nstead> Ren	der Color	124-158	8,411,488	8,411,488	24,335,648	13,051,739	919,645	CBColorAndMaskMritten CBMemRead		Can the			8 0 000 8	Non New
387		ResourceBarrie	er(3,) {1	this->ID3D	12GraphicsC	124	0	0	080.130	0	0	X CBMenWritten		6M			- hand - hand	and the second
389		DrawIndexedIns	stanced(5458. stanced(5616	1.1.54582.0	(015-)10 (0) (this-	125	39.624	30.624	317,280	194.347	7,215	CBSIowPixelCount AMD: ComputeShader		a second	1			ha -
395		DrawIndexedIns	stanced(5306	4,1,60198,	0,0) {this	127	83,040	83,040	1,109,024	283,204	24,084	AMD: DepthAndStencil						
398		DrawIndexedIns	stanced(1225	8,1,113262	,0,0) {thi	128	542,240	542,240	816,640	665,313	25,718	AMD: GeometryShader	1000					
401		DrawIndexedIns	stanced(5068	8,1,125520	,0,0) {thi	129	0	0	616,320	40,287	13,256	AMD: HullShader						
404		DrawIndexedIns	stanced(870,	1,176208,0	,0) {this-	130	135,744	135,744	581,216	329,573	14,293	AMD: PixelShader						
400		DrawIndexedIns	stanced(7368	.1.178596.0	0,0) (this	131	5,045,040	5,045,040	186,240	9,602	3,005	AMD: PrimitiveAssembly						
412		DrawIndexedIns	stanced(1762)	8,1,185964	,0,0) {thi	133	575,424	575,424	998,848	366,123	27,752	AMD: TextureOnit						
415		DrawIndexedIns	stanced(8448	,1,203592,	0,0) {this	134	938,016	938,016	1,813,568	1,188,494	79,544	AMD: VertexShader						
418		DrawIndexedIns	stanced(2313	6,1,212040	,0,0) {thi	135	190,784	190,784	682,592	85,298	11,840	D3D: Depth Occlusion     D3D: Display Control on						
421		DrawIndexedIns	stanced(48,1	,235176,0,0	0) {this->:	136	0	02 024	1,728	172 566	17 260	D3D: Pipeline statistics     D3D: Stream Output Statistics	- 10					
424		DrawIndexedIns	stanced(21204 stanced(2648	4,1,235224	0.0) (this	137	93,024	93,024	63,488	3,233	1,925		•					
430		DrawIndexedIns	stanced(15,1	,259128,0,	0) {this->	139	2,069,024	2,069,024	2,538,976	4,355,959	223,388							
433		DrawIndexedIns	stanced(5644	5,1,259143	,0,0) {thi	140	0	0	1,137,536	56,958	17,840							
435		DrawIndexedIns	stanced(1231)	2,1,315588	,0,0) {thi	141	0	0	281,792	14,393	4,565							
438		DrawIndexedIns	stanced(54,1	,327900,0,1	0) {this->	142	0	0	2,816	103	32	-	11	020×1057				
											,							
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## AMD

### Wavefront occupancy - Execution stage utilization



# Microsoft<sup>®</sup> PIX for Windows – AMD support

Graphics debugging and perf tuning tool

– DirectX<sup>®</sup> 12 on Windows 10

### AMD-specific GPU data

- Event list counters
- Wavefront occupancy (SQTT)
- High frequency counters (SPM)

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401	DrawIndexedInstanced(50688,1,125520,0,0) {this	129	0	0	616,320	40,287	13,256	AMD: GlobalMemory	6 selected				
404	DrawIndexedInstanced(870,1,176208,0,0) {this->	130	135,744	135,744	581,216	329,573	14,293	AMD: HullShader					
406	DrawIndexedInstanced(1518,1,177078,0,0) {this-	131	3,043,040	3,043,840	3,431,616	3,790,288	228,053	AMD: PrimitiveAssembly					
489	DrawIndexedInstanced(7368,1,178596,0,0) {this-	132	0	0	186,240	9,602	3,006	AMD: TextureUnit					
412	DrawIndexedInstanced(17628,1,185964,0,0) {this DrawIndexedInstanced(8448.1.203592.0.0) (this-	133	938,016	938,016	1,813,568	1.188.494	27,752	AMD: Timing     AMD: VertexShader					
418	DrawIndexedInstanced(23136,1,212040,0,0) {this	135	190,784	190,784	682,592	85,298	11,840	D3D: Depth Occlusion					
421	DrawIndexedInstanced(48,1,235176,0,0) {this->I	136	0	0	1,728	45	15	D3D: Pipeline Statistics					
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430	DrawIndexedInstanced(56445,1,259128,0,0) {this DrawIndexedInstanced(56445,1,259143,0,0) {this	139	2,009,024	2,005,024	1,137,536	4,355,959	17,840						
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# High frequency counters (HFC): ns execution sampling



# Microsoft<sup>®</sup> PIX for Windows – AMD support

### **Graphics debugging and perf tuning tool**

DirectX<sup>®</sup> 12 on Windows 10

### AMD-specific GPU data

- Event list counters
- Wavefront occupancy (SQTT)
- High frequency counters (SPM)

#### **Displayed data**

– Includes driver + GPU work

#### **Supported GPUs**

Radeon<sup>™</sup> VII, Radeon<sup>™</sup> Vega, Radeon<sup>™</sup> RX400 and RX500, and Intel Core i7 Radeon<sup>™</sup> RX Vega M

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### AGENDA

### Radeon<sup>™</sup> GPU Analyzer Amit Ben-Moshe

Introduction

RGA for Vulkan<sup>™</sup>

A look at the UI

The RGA layer

# What is Radeon GPU Analyzer

### **Compiler and code analysis tool**

- Generate GCN ISA and IL disassembly
- Retrieve shader HW resource usage
- Static analysis
- Independent of the installed HW
- Designed to support both Linux<sup>®</sup> and Windows<sup>®</sup>
- ✓ Designed to support multiple APIs: Vulkan<sup>™</sup>, DirectX<sup>®</sup>11, OpenGL<sup>™</sup>, OpenCL<sup>™</sup>

# Integration with other tools

### Integrated into tools you love

RenderDoc, Shader Playground, CodeXL, Pyramid

Shader Playground Created by Tim Jones		Updated on 2019-01-20 Arre Perma	ink
HLSL v	Compiler options	#1 - Radeon GPU Analyzer 🔻 Disassembly	Compilation summary
1 struct PSInput 2 { 3 float4 color : COLOR; 4 }; 5	Compiler #1 Radeon GPU Analyzer V	; Disassembly shader main asic(GFX9) type(PS)	// s_ps_state in s0
<pre>6 float4 PSMain(PSInput input) : SV_TARGET 7 { 8 return input.color; 9 }</pre>	2.0.1	s_mov_b32 m0, s2 s_nop 0x0000 v interp p1 f32 v2, v0, attr0.x	// 000000000000: BEFC0002 // 000000000004: BF800000 // 00000000008: D4080000
	ASIC	<pre>v_interp_p2_f32 v2, v1, attr0.x v_interp_p1_f32 v3, v0, attr0.y v_interp_p2_f32 v3, v1, attr0.y v_interp_p2_f32 v3, v1, attr0.y</pre>	// 000000000000: D4090001 // 00000000010: D40C0100 // 00000000014: D40D0101 // 00000000014: D40D0101
	Entry point PSMain	<pre>v_interp_p2_f32 v4, v1, attr0.z v_interp_p1_f32 v0, v0, attr0.w v_interp_p2_f32 v0, v1, attr0.w v_crt_ptr_z_f16 f32 v1, v2 v3</pre>	// 00000000010: D4100200 // 000000000010: D4110201 // 000000000020: D4000300 // 00000000024: D4010301 // 000000000028: D2960001 00020
	Target profile ps_5_0	v_cvt_pkrtz_f16_f32 v0, v4, v0 exp mrt0, v1, v1, v0, v0 done compr vm s_endpgm end	// 00000000030: D2960000 00020 // 00000000038: C4001C0F 00000 // 00000000040: BF810000

### RGA 2.1 for Vulkan<sup>™</sup>

### New approach for shader optimization

▲ Uses the live AMD driver compiler rather than offline compiler:

What you see is what you get

Compiler updates as you update the driver

✓ Vulkan<sup>™</sup> app creates and compiles **Vulkan<sup>™</sup> pipelines** 



## RGA for Vulkan<sup>™</sup>

### **Pipeline state**

- ▲ JSON representation
  - VkGraphicsPipelineCreateInfo for graphics (.gpso)
  - VkComputePipelineCreateInfo for compute (.cpso)
- ✓ Edit/Compose Vulkan<sup>™</sup> state in UI

#### **Pipeline State Editor**

The Vulkan graphics state for the current pipeline. State can be edited manually or intercepted from a Vulkan app using the RGA layer. For more info about the RGA layer, refer to the RGA help manual.

writeMask	0
reference	0
minDepthBounds	0
maxDepthBounds	1
✓ pColorBlendState	
flags	0
logicOpEnable	
logicOp	VK_LOGIC_OP_NO_OP
✓ pAttachments	+
✓ 0 VkPipelineColorBlendAttachmentState	
blendEnable	
srcColorBlendFactor	VK_BLEND_FACTOR_ONE
dstColorBlendFactor	VK_BLEND_FACTOR_ZERO
colorBlendOp	VK_BLEND_OP_ADD
srcAlphaBlendFactor	VK_BLEND_FACTOR_ONE
dstAlphaBlendFactor	VK_BLEND_FACTOR_ZERO
alphaBlendOp	VK_BLEND_OP_ADD
colorWriteMask	(15) 1111
✓ blendConstants	
blendConstants[0]	0
blendConstants[1]	0

# The new RGA UI

### Startup window

Select your API of choice

💫 Radeon GPU Ana	alyzer X	
Please select your tar	get API:	
Vulkan	Description:	
OpenCL	Compile and analyze graphics and compute Vulkan pipelines, from SPIR-V or GLSL files.	
Do not ask me aga	ain Start RGA Exit	

# Create new graphics/compute pipeline

### Home page

Start by creating a graphics or compute pipeline

🔕 Radeon GPU Analyzer - Vulkan

File Edit Build Help

START SETTINGS

#### Hello, welcome to the Radeon GPU Analyzer!

#### Start

Create new Vulkan graphics pipeline Create new Vulkan compute pipeline

#### Recent

No recent sessions Open .rga file from explorer...

#### Help

About RGA Help manual Getting started guide

### Add shaders

### **Two choices**

- Create template GLSL shader using RGA
- Load or drag & drop existing shader file (GLSL / SPIR-V)

l

# Edit GLSL / SPIR-V code

- Syntax highlighting
- Find text
- Jump to line
- Open header files (GLSL)

```
/* Auto-generated with Radeon GPU Analyzer (RGA).*/
   #version 450
 2
 3
   #extension GL_GOOGLE_include_directive : require
 4
   #extension GL_ARB_separate_shader_objects : enable
 5
 6
 7
   out gl PerVertex
 8
   ł
       vec4 gl Position;
 9
10 };
11
12
   layout(location = 0) out vec3 fragColor;
13
14 void main()
15 {
       float x = -1.0 + float((gl VertexIndex & 1) << 2);
16
17
       float y = -1.0 + float((gl_VertexIndex \& 2) << 1);
       gl_Position = vec4(x, y, 0, 1);
18
19
20
       fragColor = vec3(1.0f, 0.0f, 0.0f);
21 }
22
```

# SPIR-V binary editing

### **Drop SPIR-V binary in RGA**

- Binary disassembled
- Syntax highlighted
- Edit and reassemble
- Revert to original

	; SPIR-V
	; Version: 1.0
	; Generator: Khronos Glslang Reference Front End; 1
	; Bound: 172
	; Schema: 0
	OpCapability Shader
	OpCapability ImageQuery
	<pre>%1 = OpExtInstImport "GLSL.std.450"</pre>
	OpMemoryModel Logical GLSL450
3	OpEntryPoint Fragment %main "main" %inUV %outFragColor
L	OpExecutionMode %main OriginUpperLeft
2	OpSource GLSL 450
3	<pre>OpSourceExtension "GL_ARB_separate_shader_objects"</pre>
1	OpSourceExtension "GL_ARB_shading_language_420pack"
5	OpName %main "main"
5	OpName %weight "weight"
7	OpName %tex_offset "tex_offset"
3	OpName %samplerColor "samplerColor"
9	OpName %UBO "UBO"
3	OpMemberName %UBO 0 "blurScale"
L	OpMemberName %UBO 1 "blurStrength"
2	OpName %ubo "ubo"
3	OpName %result "result"
1	OpName %inUV "inUV"
5	OpName %i "i"
5	OpName %outFragColor " <mark>outFragColor</mark> "
7	OpDecorate %samplerColor DescriptorSet 0
3	OpDecorate %samplerColor Binding 1
9	OpMemberDecorate %UBO 0 Offset 0
3	OpMemberDecorate %UBO 1 Offset 4
L	OpDecorate %UBO Block
2	OpDecorate %ubo DescriptorSet 0
3	OpDecorate %ubo Binding 0
1	OpDecorate %inUV Location 0

# Configure the pipeline state

- ▲ Graphical representation of the Vulkan<sup>™</sup> pipeline state as a tree
- Easy search and navigation
- Filter the state
- Edit the state

#### **Pipeline State Editor**

The Vulkan graphics state for the current pipeline. State can be edited manually or intercepted from a Vulkan app using the RGA layer. For more info about the RGA layer, refer to the RGA help manual.

✓ pColorBlendState	
flags	0
logicOpEnable	
logicOp	VK_LOGIC_OP_NO_OP
✓ pAttachments	+
✓ 0 VkPipelineColor <mark>Blend</mark> AttachmentState	<b>W</b>
<mark>blend</mark> Enable	
srcColor <mark>Blend</mark> Factor	VK_BLEND_FACTOR_ONE
dstColor <mark>Blend</mark> Factor	VK_BLEND_FACTOR_ZERO
color <mark>Blend</mark> Op	VK_ <mark>BLEND</mark> _OP_ADD
srcAlpha <mark>Blend</mark> Factor	VK_BLEND_FACTOR_ONE
dstAlpha <mark>Blend</mark> Factor	VK_BLEND_FACTOR_ZERO
alpha <mark>Blend</mark> Op	VK BLEND OP ADD
colorWriteMask	(13) 1101
✓ blendConstants	VK_COLOR_COMPONENT_R_BIT
blend <mark>Constants[0]</mark>	
blend <mark>Constants[1]</mark>	VK_COLOR_COMPONENT_A_BIT
blend <mark>Constants[2]</mark>	c
blend <mark>Constants[3]</mark>	0
subpass	0
basePipelineIndex	-1
VkPipelineLayoutCreateInfo	
flags	0
Load pipeline state	

# Configure the build settings

#### Type product name to filter

General		🔕 s	elect Target GPUs		×
Target GPUs:	gfx906	Sear	rch GPU architecture, compute capability, or pr	oduct name: 55	50
Predefined macros: Additional include directories:	Add include director		Product name AMD Embedded Radeon E9170 Series AMD Embedded Radeon E9171	Architecture Graphics IP v8 Graphics IP v8	Compute capability gfx804 gfx804
Vulkan runtime settings ICD location:  Enable validation layers Eront-end compiler settings (alslang)	C:/VulkanSDK/1.1.92.1, C:/Shaders/Vulkan C:/Shaders/Vulkan/inc C:/Shaders/Common/i		AMD Radeon Pro WX 2100 AMD Radeon Pro WX 3100 Radeon 500 Series Radeon 540 Series Radeon 550 Series Radeon Pro WX 2100 Radeon Pro WX 3100 Radeon RX Vega M GH Graphics	Graphics IP v8 Graphics IP v8	gfx804 gfx804 gfx804 gfx804 gfx804 gfx804 gfx804 gfx804
Additional gIslang options: Use alternative front-end compiler package: Settings command line			Radeon RX Vega M GL Graphics	Graphics IP v8	gfx804
					OK Cancel

# Build the pipeline

eline name: 20190214-175827		🖍 🗸 🗸 gfx906 (V	ega) 📔 🗸 Columns			
ert (src.vert)	1 /* Auto-generated with Radeon GPU Analyzer (RGA).*/ 2 #version 450	Address 0x000000	Opcode v add u32	Operands v0, s3, v0	Functional unit Vector ALU	Cycles 4
esc +	3 4 #extension GL_GOOGLE_include_directive : require 5 #extension GL_ARB separate shader objects : enable	0x000004 0x000008	v_and_b32 v_lshlrev_b32 v_out_f32_i32	v1, 1, v0 v1, 2, v1	Vector ALU Vector ALU	4 4
ese 🕇	6 7 out gl_PerVertex	0x000010 0x000014	v_cvt_132_132 v_add_f32 v_and_b32	v1, -1.0, v1 v0, 2, v0	Vector ALU Vector ALU	4 4 4
eom 🕂	<pre>8 { 9 vec4 gl_Position; 10 };</pre>	0x000018 0x00001C 0x000020	v_lshlrev_b32 v_cvt_f32_i32 v_add_f32	v0, 1, v0 v0, v0 v0, -1,0, v0	Vector ALU Vector ALU Vector ALU	4 4 4
ag 🕂	<pre>11 12 layout(location = 0) out vec3 fragColor; 12 layout(location = 0)</pre>	0x000024 0x000028	v_mov_b32 v_mov_b32	v2, 0 v3, 1.0	Vector ALU Vector ALU	4 4
Pipeline state	13 14 void main() 15 {	0x00002C 0x000034 0x00003C	exp exp s_endpgm	pos0, v1, v0, v2, v3 done param0, v3, v2, v2, off	Scalar Memory Scalar Memory Flow Control	Varies Varies 1
Ruild sattings	<pre>1 16</pre>					
	19 20 fragColor = vec3(1.0f, 0.0f, 0.0f); 21 }					
	22					
		Resource usag	ge   <b>VGPRs:</b> 4 / 256   <b>SG</b>	PRs: 7 / 104   LDS: 0 / 32 KB   Scratch me	emory: 0 B	
ld output						-
ilding Vulkan project "2019	)214-175827" for gfx906					
a.exe -s vulkanisa "C:\U D190214-175827\Output\Clone 1-20190214-155141.log"se 190214-175827/Clone0/Pipeli	<pre>ers\abenmos\Documents\RadeonGFUAnalyzer\Projects\20190214-175827\Output\Clone0\disassem.txt"parse-in \\resourceUsage.csv" -b "C:\Users\abenmos\Documents\RadeonGFUAnalyzer\Projects\20190214-175827\Output\C sion-metadata "C:\Users\abenmos\Documents\RadeonGFUAnalyzer\Projects\20190214-175827\Output\Clone0\gfx he0.gpso"vert "C:/Users\abenmos\Documents/RadeonGFUAnalyzer/Projects/20190214-175827\Clone0/src.vert</pre>	isaline-numbers Clone0\codeobj.bin x906_cliInvocation. ;"	analysis "C:\Use 'log "C:\Users\a .xml"asic gfx906	ers\abenmos\Documents\RadeonGPUAr ubenmos\AppData\Roaming\RadeonGPU 6pso "C:/Users/abenmos/Documer	nalyzer\Projects JAnalyzer\rga- nts/RadeonGPUAnaly:	zer/Project
rget GPU detected:						
x906 (Vega)						
	.le (C:/Users/abenmos/Documents/RadeonGPUAnalyzer/Projects/20190214-175827/Clone0/src.vert) to SPIR-V b ded.	pinary succeeded	1.			
e-compiling vertex shader f ilding for gfx906 succee						
e-compiling vertex shader f Ilding for gfx906 succee						

### Examine the disassembly and resource usage

- Disassembly and resource usage in the same view
- Breaks down each instruction into its components
- Color coding by instruction class
- Resource usage hazards highlighted as warnings
  - A Resource usage | VGPRs: 256 / 256 -> 29 spills | SGPRs: 79 / 102 | LDS: 0 / 64 KB | Scratch memory: 120 B | Instruction cache: 60168 B

💙 gfx906 (Veg	ia) 📔 💙 Columns			
Address	Opcode	Operands	Functional unit	Cycles
0x000004	s_mov_b32	s6, s3	Scalar ALU	4
0x000008	s_mov_b32	s7, s1	Scalar ALU	4
0x00000C	s_load_dwordx4	s[8:11], s[6:7], 0x00	Scalar Memory	Varies
0x000014	s_load_dwordx4	s[12:15], s[6:7], 0x20	Scalar Memory	Varies
0x00001C	s_mov_b32	s0, s2	Scalar ALU	4
0x000020	s_load_dwordx4	s[0:3], s[0:1], 0x00	Scalar Memory	Varies
0x000028	s_waitcnt	lgkmcnt(0)	Flow Control	Varies
0x00002C	<pre>s_buffer_load_dwordx8</pre>	s[16:23], s[0:3], 0x00	Scalar Memory	Varies
0x000034	<pre>s_buffer_load_dwordx8</pre>	s[24:31], s[0:3], 0x20	Scalar Memory	Varies
0x00003C	<pre>s_buffer_load_dwordx8</pre>	s[32:39], s[0:3], 0x40	Scalar Memory	Varies
		( aava 1 , s[0:3], 0x60	Scalar Memory	Varies
120 B   IUS	struction cache: 60168 B	32KB   , s[0:3], 0x80	Scalar Memory	Varies
0x000054	v_add_u32	v0, s4, v0	Vector ALU	4
0x000058	s_waitcnt	lgkmcnt(0)	Flow Control	Varies
0x00005C	v_mov_b32	v1, s32	Vector ALU	4
0x000060	v_mul_f32	v2, s16, v1	Vector ALU	4
0x000064	v_mul_f32	v3, s17, v1	Vector ALU	4
0x000068	v_mul_f32	v4, s18, v1	Vector ALU	4
0x00006C	v_mul_f32	v1, s19, v1	Vector ALU	4
0x000070	v_mov_b32	v5, s33	Vector ALU	4
0x000074	v_fmac_f32	v2, s20, v5	Vector ALU	Varies
0x000078	v_fmac_f32	v3, s21, v5	Vector ALU	Varies
0x00007C	v_fmac_f32	v4, s22, v5	Vector ALU	Varies
axaaaasa	v fmac f22	v1 c23 v5	Vector All	Varies

Resource usage | VGPRs: 35 / 256 | SGPRs: 58 / 104 | LDS: 0 / 64 KB | Scratch memory: 0 B |

# How can I get my app's shaders into RGA?

### **Use the RGA layer – beta feature**

- ✓ Implicit Vulkan<sup>™</sup> layer
- Serializes state and shaders for all pipelines
- Can intercept specific pipelines if VK\_EXT\_DEBUG\_MARKER is used

# Using the RGA Layer

### **Suggested RGA workflow**

- ▲ Good idea to use VK\_EXT\_DEBUG\_MARKER to name your objects
- Identify your bottleneck pipeline using a profiler or debugger like RenderDoc
- Suppose pipeline "blurOne" was identified as a bottleneck
- Can you locate your shaders? Just drop them in RGA
- Can't locate shaders or don't feel like manually editing the state?
  - Use the RGA layer

RGA Layer Launcher		_			2
/ulkan app					
Executable:	$\verb C:vesearch\SaschaWillems\Vulkan\bin\Release\bloom.exe   \\$				
Working directory:					
Environment variables:					
ayer Output directory:	C:\LayerOutput\Bloom				
Pipeline names:	blurOne		]		
		Open output folder		Launch	



### Drop serialized files in RGA

Name	Date modified	Туре
📋 rgaPso1_blurOne.gpso	2/5/2019 11:59 AM	GPSO File
rgaPso1_blurOne_frag_main.spv	2/5/2019 11:59 AM	SPV File
rgaPso1_blurOne_vert_main.spv	2/5/2019 11:59 AM	SPV File

🔕 Radeon GPU Analyzer - Vulkan Proje	ct - blurVert
File Edit Build Help	
Pipeline name: blurVert	
vort (rapDco1 bl. in cnv)	1 ; SPIR-V
vert (rgapsor_biin.spv)	2 ; Version: 1.0
	3 ; Generator: Khronos Gislang Reference Front End; 1
tesc +	4 ; Bound: 40
	6 OnCanability Shader
tese +	7 $\%1 = OpExtInstImport "GLSL_std_450"$
	8 OpMemoryModel Logical GLSL450
geom 🗕	9 OpEntryPoint Vertex %main "main" %outUV %gl VertexIndex %
J	10 OpSource GLSL 450
	11 OpSourceExtension "GL ARB separate shader objects"
frag (rgaPso1_blin.spv)	12 OpSourceExtension "GL ARB shading language 420pack"
	13 OpName %main "main"
	14 OpName %outUV "outUV"
Pipeline state	15 OpName %gl_VertexIndex "gl_VertexIndex"
•	16 OpName %gl_PerVertex "gl_PerVertex"
	17 OpMemberName %gl_PerVertex 0 "gl_Position"
<b>*</b>	18 OpName %_ ""
Build settings	19 OpDecorate %outUV Location 0
	20 OpDecorate %gl_VertexIndex BuiltIn VertexIndex
	21 OpMemberDecorate %gl_PerVertex 0 BuiltIn Position
	22 OpDecorate %gI_PerVertex Block
	23 %vold = UplypeVold
	24 %3 = OplypeFunction %void
	25 % float = Up yperioat 32
	20 %v2t10al = Oplypevector %t10al 2 27 % nth Output v2float = Oplypevector %t10al 2
	27 *_ptr_output_vzridat = opryperofilter output vzridat
	29 %int = OnTypeInt 32 1
	30 % ntr Input int = OnIvnePointer Input %int
	31 %el VertexIndex = OpVariable % ptr Input int Input
	32 %int 1 = OpConstant %int 1
	33 %int 2 = OpConstant %int 2
	34 %v4float = OpTypeVector %float 4

#### Build output

Disassembling SPIR-V binary: C:\LayerOutput\Bloom\rgaPsol\_blurVert\_vert\_main.spv... succeeded.

Disassembling SPIR-V binary: C:\LayerOutput\Bloom\rgaPsol\_blurVert\_frag\_main.spv... succeeded.

### Build, tweak GLSL / SPIR-V, tweak pipeline state, repeat!

💫 Radeon GPU A	Analyzer - Vulkan Project - blurVert					- 0	×
File Edit	Build Help		1	✓ gfx906 (Ve	ega) 📔 🗸 Columns		1
	Build project	Ctrl+Shift+B		Address	Opcode	Operands	^
Pipeline r	Pipeline state	F9		0x000000	s getpc b64	s[6:7]	
	ripenie state	ront End; 1		0x000004	s_mov_b32	m0, s3	
	Build settings	F8 SPIR-V	e	0x000008	s_mov_b64	s[16:17], exec	
vert (rg	Concol build	Ctrlushiftic Version: 1	e e e e e e e e e e e e e e e e e e e	0x00000C	s_wqm_b64	exec, exec	
	Cancel build			0X000010	s_mov_b32	s0, s2	
		3 ; Generator:	e	0x000014	s load dwordx8	s[4:11], s[0:1], 0x10	
tesc		4 : Bound: 1723L450		0x000020	v mov b32	v2, 0	
		in "main" %inUV %outFra	gColor e	0x000024	s_waitcnt	lgkmcnt(0)	
trag (rgaPso1	blin.spy)	, SCHEMA. V iginUpperLeft		0x000028	<pre>image_get_resinfo</pre>	v2, v2, s[4:11] dmask:0x2	
	12	OpSource GLSL 450		0x000030	s_load_dwordx4	s[12:15], s[0:1], 0x00	
	13	OpSourceExtension "GL_ARB_separate_shader_object	s" (6	0x000038	s_waitcnt	lgkmcnt(0)	
<b>6</b>	14	OpSourceExtension GL_AKB_shading_language_420pa	CK [6	0x00003C	s_butter_load_dwordx2	s[2:3], s[12:15], 0x00	
Pipeline stat	15 15	OpName %weight "weight"	e	0X000044	s_waitcht	vmcnt(0)	
	17	OnName %tex offset "tex offset"		0x000046	V_CVL_T52_152		
	18	OpName %samplerColor "samplerColor"		0x000004C	s load dwordxA	$\sqrt{2}$ , $\sqrt{2}$ s[12:15] s[0:1] 0x30	
🛛 💭 Build setting	<b>IS</b> 19	OpName %UBO "UBO"	e	0x000058	v interp p1 f32	$v_{28}$ , $v_{0}$ , attr0.v	
	20	OpMemberName %UBO 0 "blurScale"	ē	0x00005C	v interp p1 f32	v0, v0, attr0.x	
	21	OpMemberName %UBO 1 "blurStrength"	e	0x000060	v interp p2 f32	v28, v1, attr0.y	
	22	OpName %ubo "ubo"	e	0x000064	v_interp_p2_f32	v0, v1, attr0.x	
	23	OpName %result "result"	6	0x000068	s_waitcnt	lgkmcnt(0)	
	24	OpName %inUV "inUV"	6	0x00006C	v_mad_f32	v6, v2, s2, v28	
	25	OpName %i "i"	e	0x000074	v_mul_f32	v4, s2, v2	
	26	OpName %outFragLolor OutFragLolor	e	0x000078	v_mov_b32	v5, v0	
	27	OpDeconate %samplerColor Descriptorset 0	le l	0x00007C	image_sample	v[5:/], v[5:/], s[4:11], s[12:15] dmask:0x/	
	20	OpMemberDecorate %UBO 0 Offset 0		0X000084	V_mad_T32	V12, -V2, S2, V28	
	30	OpMemberDecorate %UB0 1 Offset 4		02000000	v_mu1_T32	vz, z.v, v4 v17 v2 v28	
	31	OpDecorate %UBO Block		0x0000094	v_mov_b32	v27. v0	$\sim$
	32	OpDecorate %ubo DescriptorSet 0		<			>
	33	OpDecorate %ubo Binding 0					
	34	OpDecorate %inUV Location 0	$\sim$	Resource usag	e   VGPRs: 31 / 256   SGPRs: 20 / 1	104   LDS: 0 / 32 KB   Scratch memory: 0 B	

#### Build output

\clone0\resourceUsage.csv" -b "C:\Users\abenmos\Documents\RadeonGPUAnalyzer\Projects\blurVert\Output\Clone0\codeobj.bin" --log "C:\Users\abenmos\AppData\Roaming\RadeonGPUAnalyzer\Projects\blurVert\Output\Clone0\prodeobj.bin" --log "C:\Users\abenmos\Documents\RadeonGPUAnalyzer\Projects\blurVert\Output\Clone0\prodeobj.bin" --log "C:\Users\abenmos\Documents\RadeonGPUAnalyzer\Projects\blurVert\Output\Clone0\prodeobj.bin" --log "C:\Users\abenmos\Documents\RadeonGPUAnalyzer\Projects\blurVert\Output\Clone0\prodeobj.bin" --log "C:\Users\abenmos\Documents\RadeonGPUAnalyzer\Projects\blurVert\Output\Clone0\prodeobj.bin" --vert "C:\LayerOutput \bloom\prodeobj.bin" --pos "C:\Users\abenmos\Documents\RadeonGPUAnalyzer\Projects\blurVert\Clone0\prodeobj.bin" --vert "C:\LayerOutput \bloom\prodeobj.bin" --pos "C:\Users\abenmos\Documents\Prodeobj.bin" --pos "C:\User --pos "C:\Users\abenmos\Documents\Pr

Target GPU detected:

gfx906 (Vega)

Building for gfx906... succeeded.

≚ 🌛

### RGA for Vulkan – key takeaways

- Compile through the live-driver
- Edit GLSL source code or SPIR-V binaries
- Edit Vulkan pipeline state with graphical editor
- Extract state/shaders from apps with the layer beta feature
- ▲ Highlights VMEM, SMEM instructions, and excessive HW resource usage
- Runs on non-AMD configurations as well

# Thank you!

# **Questions?**

### Information

GPUOpen: <u>https://gpuopen.com/</u>

RGP: <u>https://gpuopen.com/gaming-product/radeon-gpu-profiler-rgp/</u>

RGA: <u>https://gpuopen.com/gaming-product/radeon-gpu-analyzer-rga/</u>

RenderDoc: <u>https://renderdoc.org</u>

Microsoft<sup>®</sup> PIX: <u>https://blogs.msdn.microsoft.com/pix</u>

### **Downloads**

RGP: <u>https://github.com/GPUOpen-Tools/RGP/releases</u> RGA: <u>https://github.com/GPUOpen-Tools/RGA/releases</u>

### Acknowledgements

Baldur Karlsson for assistance with RenderDoc-RGP and RGA interop Gregory Mitrano for RGP content

#### Contact

Rodrigo.Urra@amd.com Amit.Ben-Moshe@amd.com

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