Jaguar (microarchitecture)

The **AMD Jaguar Family 16h** is a low-power microarchitecture designed by AMD. It is used in APUs succeeding the Bobcat Family microarchitecture in 2013 and being succeeded by AMD's Puma architecture in 2014. It is two-way superscalar and capable of out-of-order execution. It is used in AMD's Semi-Custom Business Unit as a design for custom processors and is used by AMD in four product families: *Kabini* aimed at notebooks and mini PCs, *Temash* aimed at tablets, *Kyoto* aimed at micro-servers, and the *G-Series* aimed at embedded applications. Both the PlayStation 4 and the Xbox One use chips based on the Jaguar microarchitecture, with more powerful GPUs than AMD sells in its own commercially available Jaguar APUs.[2]

Jaguar - Family 16h

General information	
Launched	Mid-2013
Discontinued	present
Common manufacturer(s)	AMD
Cache	
L1 cache	64 KB per core[1]
L2 cache	1 MB to 2 MB shared
Architecture and classification	
Technology node	28 nm
Instruction set	AMD64 (x86-64)
Physical specifications	
Socket(s)	Socket AM1 Socket FT3 (BGA-769)
Products, models, variants	
Core name(s)	Kabini Temash Kyoto G-series Athlon, Sempron, A4, A6, & E4
History	
Predecessor(s)	Bobcat - Family 14h
Successor(s)	Puma - Family 16h (2nd-gen) CPU of Xbox One X

Design

- 32 KiB instruction + 32 KiB data L1 cache per core, L1 cache includes parity error detection
- 16-way, 1–2 MiB unified L2 cache shared by two or four cores, L2 cache is protected from errors by the use of error correcting code
- Out-of-order execution and speculative execution
- Integrated memory controller
- Two-way integer execution
- Two-way 128-bit wide floating-point and packed integer execution
- Integer hardware divider
- Consumer processors support two DDR3L DIMMs in one channel at frequencies up to 1600 MHz[3]
- Server processors support two DDR3 DIMMs in one channel at frequencies up to 1600 MHz with ECC[4]
- As a SoC (not just an APU) it integrates Fusion controller hub
- Jaguar does *not* feature clustered multi-thread (CMT), meaning that execution resources are not shared between cores

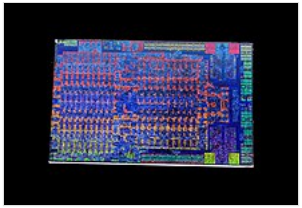
Instruction set support

The *Jaguar* core has support for the following instruction sets and instructions: MMX, SSE, SSE2, SSE3, SSSE3, SSE4a, SSE4.1, SSE4.2, AVX, F16C, CLMUL, AES, BMI1, MOVBE (Move Big-Endian instruction), XSAVE/XSAVEOPT, ABM (POPCNT/LZCNT), and AMD-V.[1]

Improvements over Bobcat

- Over 10% increase in clock frequency[5]
- Over 15% improvement in instructions per clock (IPC)[5]
- Added support for SSE4.1, SSE4.2, AES, CLMUL, MOVBE, AVX, F16C, BMI1[5]
- Up to four CPU cores
- L2 cache is shared between cores
- FPU datapath width increased to 128-bit[5]
- Added hardware integer divider
- Enhanced cache prefetchers
- Doubled bandwidth of load-store units
- C6 and CC6 low power states with lower entry and exit latency[5]
- Smaller, 3.1 mm^2 area per core
- Integrated Fusion controller hub (FCH)

- Video Coding Engine



Features

Processors

Consoles

Chip (device)	Release date	Fab	Die area (mm2)	CPU				GPU							Memory			Storage
				Archi-tecture	Cores	Clock (GHz)	L2 cache	Archi-tecture	Core config[a]	Clock (MHz)	GFLOPS [b]	Pixel fillrate (GP/s) [c]	Texture fillrate (GT/s) [d]	Other	Size	Bus type & width	Band-width (GB/s)	
Liverpool (PS4)	Nov 2013	28 nm	348	Jaguar	2 modules with 4 cores each	1.6	2× 2 MiB	GCN 2	1152:72:32 18 CU	800	1843	25.6	57.6	8 ACEs	8 GiB	GDDR5 256-bit	176	3DBD/DVD 1× 2.5" SATA hard drive Easily replaceable hard drive USB 3.0

Chip (device)	Release date	Fab	Die area (mm2)	CPU				GPU							Memory			Storage
				Archi-tecture	Cores	Clock (GHz)	L2 cache	Archi-tecture	Core config[a]	Clock (MHz)	GFLOPS [b]	Pixel fillrate (GP/s) [c]	Texture fillrate (GT/s) [d]	Other	Size	Bus type & width	Band-width (GB/s)	
Durango (Xbox One)			363			1.75			768:48:16 12 CU	853	1310	13.6	40.9	2 ACEs	32 MiB 8 GiB	ESRAM[f] DDR3 256-bit	204 68	3DBD/DVD/CD 1× 2.5" SATA hard drive USB 3.0

Chip (device)	Release date	Fab	Die area (mm2)	CPU				GPU							Memory			Storage
				Archi-tecture	Cores	Clock (GHz)	L2 cache	Archi-tecture	Core config[a]	Clock (MHz)	GFLOPS [b]	Pixel fillrate (GP/s) [c]	Texture fillrate (GT/s) [d]	Other	Size	Bus type & width	Band-width (GB/s)	
Edmonton (Xbox One S) [6]	Jun 2016	16 nm	240	Customized Jaguar	8	1.75	4 MiB	GCN 4 Polaris[10]	2304:144:32 36 CU	914	1404	14.6	43.9	4 ACEs and 2 HWS Double-rate FP16[h] checkerboard rendering	32 MiB 8 GiB	ESRAM DDR3 256-bit	219 68	4KBD/3DBD/DVD/CD[i] 1× 2.5" SATA hard drive USB 3.0
Liverpool? (PS4 Slim)	Sep 2016		208			1.6			1152:72:32 18 CU	800	1843	25.6	57.6	8 ACEs	8 GiB	GDDR5 256-bit	176	3DBD/DVD 1× 2.5" SATA hard drive Easily replaceable hard drive USB 3.0
Neo (PS4 Pro) [7][8][9]	Nov 2016		325			2.13			2304:144:32 36 CU	911	4198	58.3	131.2	4 ACEs and 2 HWS Double-rate FP16[h] checkerboard rendering	8 GiB [11] 1 GiB	GDDR5 256-bit DDR3[i]	218 ?	3DBD/DVD 1× 2.5" SATA hard drive Easily replaceable hard drive USB 3.0
Scorpio (Xbox One X) [12][13][14]	Nov 2017		359	Customized Jaguar	8	2.3		GCN 4 Polaris[10]	2560:160:32 40 CU	1172	6001	37.5	187.5	4 ACEs and 2 HWS	12 GiB	GDDR5 384-bit	326	4KBD/3DBD/DVD/CD 1× 2.5" SATA hard drive USB 3.0

a. Unified Shaders : Texture Mapping Units : Render Output Units

b. Precision performance is calculated from the base (or boost) core clock speed based on a FMA operation.
c. Pixel fillrate is calculated as the number of **ROP**s multiplied by the base (or boost) core clock speed.
d. Texture fillrate is calculated as the number of **TMU**s multiplied by the base (or boost) core clock speed.
e. UHD BD is the only video disc format supporting HDR.
f. Cache
g. "Digital" version does not have an optical drive.
h. Feature preview of Rapid Packed Math, introduced in GCN 5 Vega.
i. Swap

Desktop

SoCs using Socket AM1:

Model	CPU			GPU			TDP	DDR3	Socket
	Cores	Freq. (GHz)	L2 Cache (MB)	Model	Cores (unified shaders : texture mapping units : render output units)	Freq. (MHz)	(W)	Memory Speed	
Athlon 5370	4	2.2	2	Radeon R3	128:8:4[15]	600	25	1600	AM1
Athlon 5350[16]		2.05							
Athlon 5150		1.6							
Sempron 3850		1.3				450			
Sempron 2650	2	1.45	1			400		1333	

Desktop/Mobile (28 nm)

Target segment	Model	CPU				GPU				TDP	DDR3
		Cores	Freq. (GHz)	Turbo (GHz)	L2 Cache (MB)	Model	Config.	Freq. (MHz)	Turbo (MHz)	(W)	Memory
Notebooks /Mini-PCs[17]	A6-5200	4	2.0	—	2	HD 8400	128:8:4[18]	600	—	25	(L)1600
	A4-5100		1.55			HD 8330		500		15	
	A4-5000		1.50								
Notebooks	E2-3000	2	1.65		1	HD 8280		450			
	E1-2500		1.4			HD 8240		400			(L)1333
	E1-2100		1.0			HD 8210		300		9	
Tablets	A6-1450	4		1.4	2	HD 8250			400	8	(L)1066
	A4-1350[19]			—		HD 8210			—		1066
	A4-1250	2			1						(L)1333
	A4-1200[20]					HD 8180		225		3.9	(L)1066

Server

Opteron X1100-series "Kyoto" (28 nm)

Model	Step.	CPU	Memory support	TDP	Released	Part number	Release

		Cores	Freq. (GHz)	Turbo	L2 Cache (MB)	Multi	V_{core}		(W)			price (USD)
X1150 (https://web.archive.org/web/20150621165634/http://products.amd.com/en-us/OpteronCPUDetail.aspx?id=839)	B0	4	2.0	—	2			DDR3	17	May 2013	OX1150IPJ44HM	$64

Opteron X2100-series "Kyoto" (28 nm)

Model	Step.	CPU						GPU				DDR3	TDP	Released
		Cores	Freq. (GHz)	Turbo (GHz)	L2 Cache (MB)	Multi	V_{core}	Model	Config	Freq. (MHz)	Turbo	Memory support	(W)	
X2150 (https://web.archive.org/web/20150621165854/http://products.amd.com/en-us/WorkstationAPUDetail.aspx?id=78)	B0	4	1.9	—	2			HD 8400		800	—		22	May 2013
X2170 (https://www.amd.com/en-us/products/server/opteron-x/x2170)		4	2.4	—							—		25	September 2016

Embedded

Model	CPU	GPU	TDP	DDR3
			(W)	ECC Memory

	Cores	Freq. (GHz)	L2 Cache (MB)	Model	Config.	Freq. (MHz)		Speed
GX-420CA	4	2.0	2	HD 8400E	128:8:4	600	25	1600
GX-416RA[21][22][23][24]		1.6		—			15	
GX-415GA		1.5		HD 8330E	128:8:4	500		
GX-412TC[25]		1.0		—			6	1333
GX-411GA		1.1		HD 8210E	128:8:4	300	15	1600
GX-217GA	2	1.65	1	HD 8280E		450		
GX-210HA		1.0		HD 8210E		300	9	1333
GX-210JA				HD 8180E		225	6	1066

Jaguar derivative and successor

In 2017, a derivative of the Jaguar microarchitecture was announced in the APU of Microsoft's Xbox One X (Project Scorpio) revision to the Xbox One.[26] The Project Scorpio APU is described as a 'customized' derivative of the Jaguar microarchitecture, utilizing eight cores clocked at 2.3 GHz.[27][28]

The Puma successor to Jaguar was released in 2014 and targeting entry level notebooks and tablets.[29]

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