



Where Have All The Cycles Gone?

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Artwork by Daniel Mercadante

Adobe is Hiring



<https://cppatadobe.splashthat.com>



Sand in the Gears

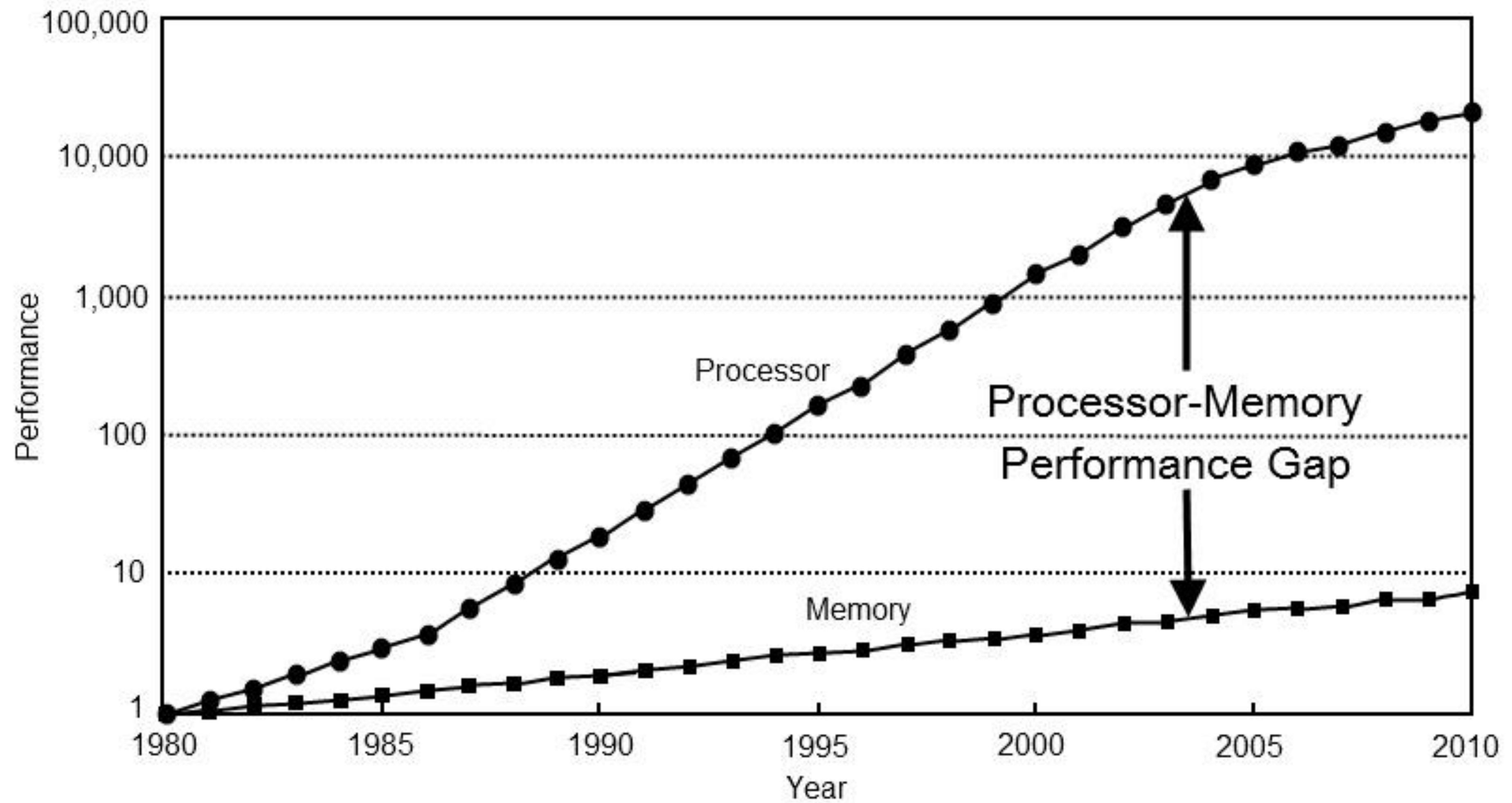
- Memory Latency
- Synchronization
- Expanded Requirements
- Programming Model



Memory Latency

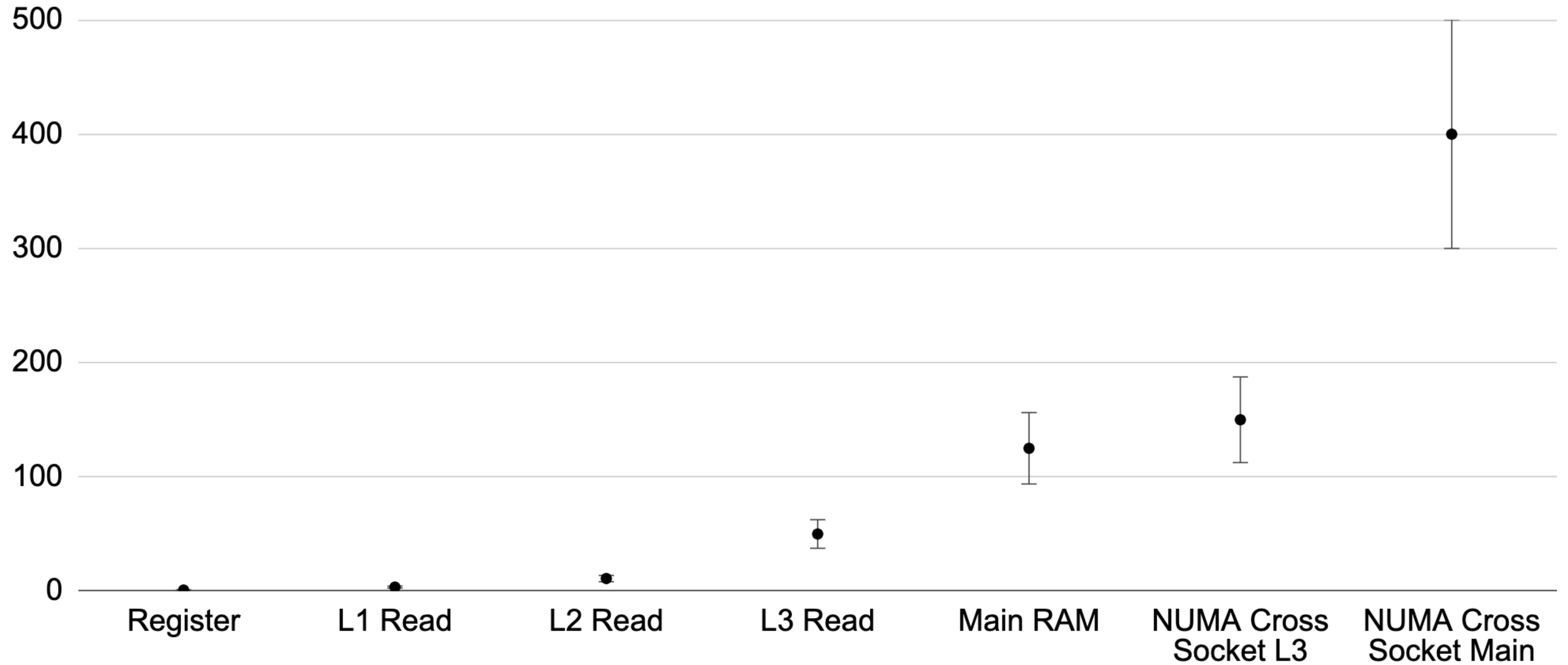


Processor-Memory Gap



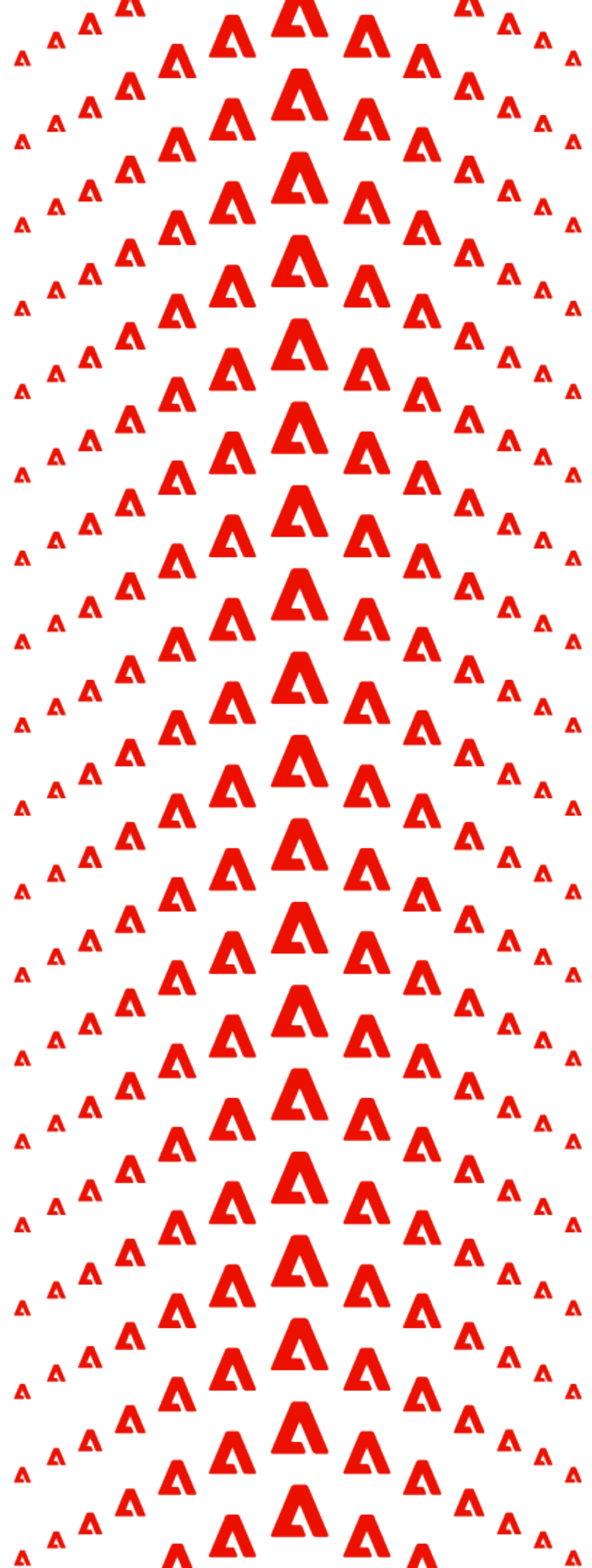
Computer Architecture: A Quantitative Approach by John L. Hennessy, David A. Patterson, Andrea C. Arpaci-Dusseau

Processor-Memory Gap



<http://ithare.com/infographics-operation-costs-in-cpu-clock-cycles/>

Synchronization



Synchronization

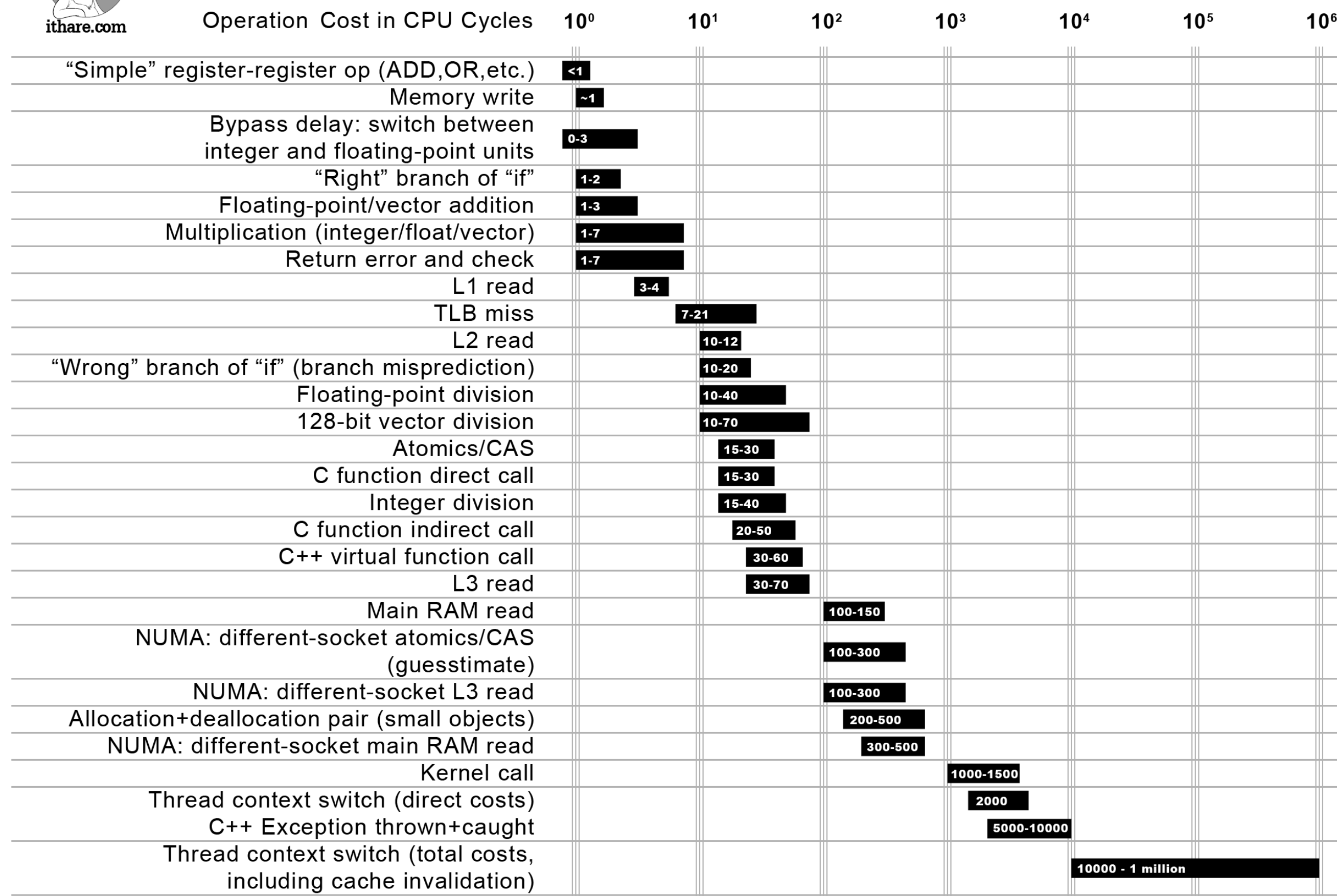
Atomics - 15-30 cycles

Mutex under contention - 1,000 - 1,500 cycles

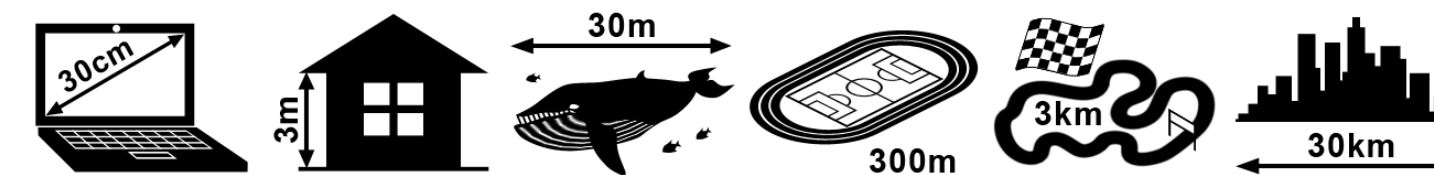
The last line is the full cost of a context switch
10,000 - 1,000,000 cycles



Not all CPU operations are created equal



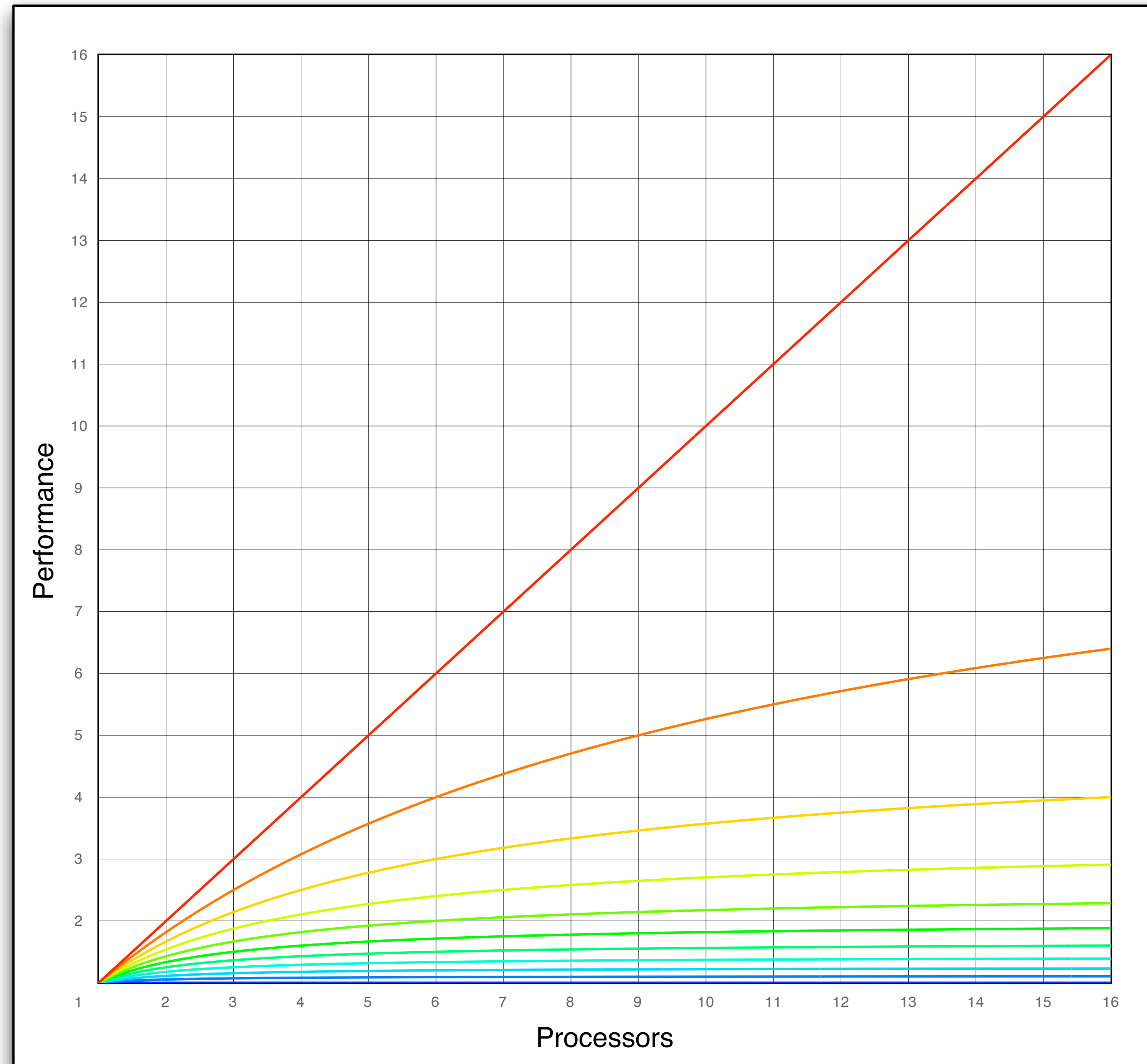
Distance which light travels while the operation is performed



<http://ithare.com/infographics-operation-costs-in-cpu-clock-cycles/>

Amdahl's Law - Cost of Synchronization

Each line represents 10% more synchronization



Expanded Requirements



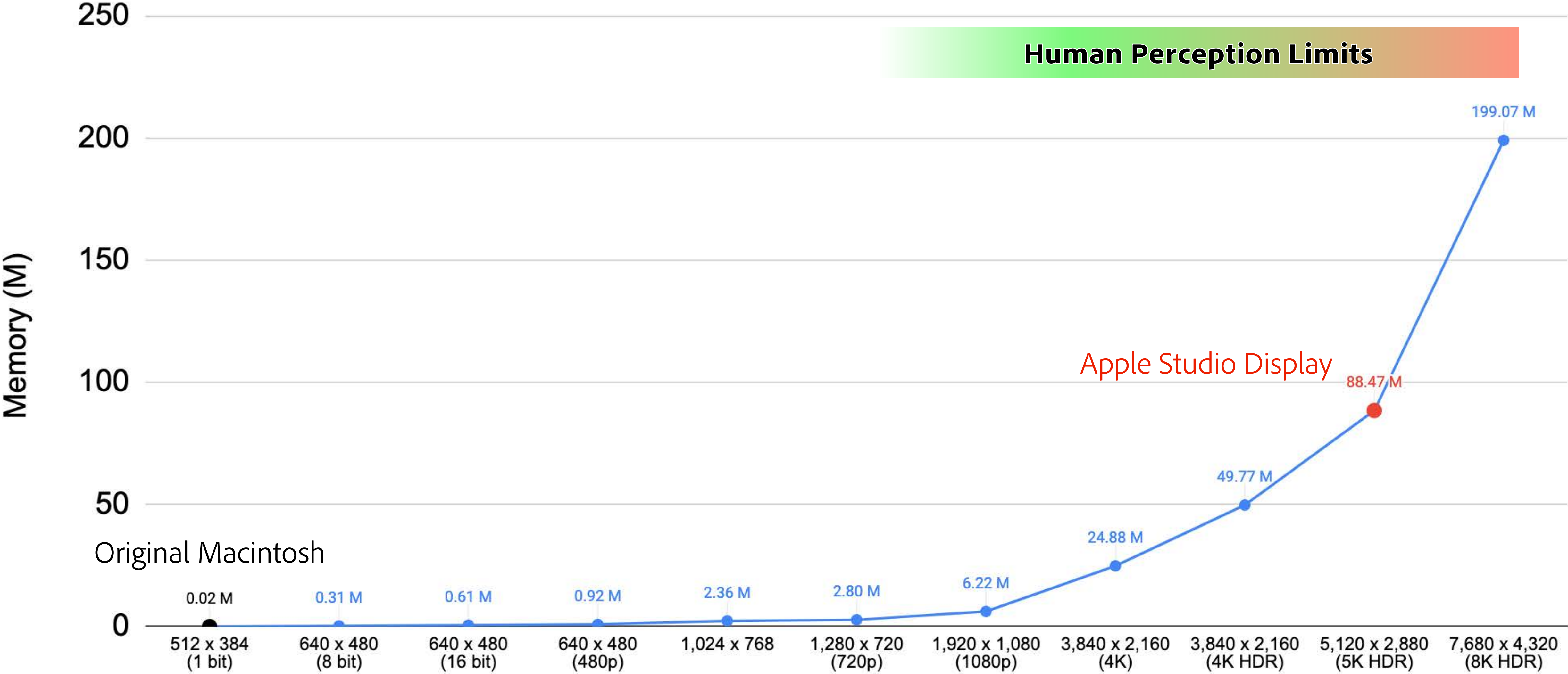
Background Processes

Name	Status	16% CPU	41% Memory	0% Disk	0% Network	6% GPU	GPU engine
Apps (8)							
> Windows Explorer		0.4%	93.2 MB	0.1 MB/s	0 Mbps	0%	
> Task Manager		0.6%	43.3 MB	0 MB/s	0 Mbps	0%	
> Slack (7)		0.6%	344.7 MB	0.1 MB/s	0 Mbps	0.2%	GPU 1 - 3D
> People (2)	🔒	1.5%	49.0 MB	0 MB/s	0 Mbps	5.6%	GPU 1 - Video Decode
> Microsoft Edge (24)		4.9%	1,892.7 MB	0.1 MB/s	0 Mbps	0.1%	GPU 1 - 3D
> Mail		0%	64.1 MB	0 MB/s	0 Mbps	0%	GPU 1 - 3D
> iTunes (7)		0%	64.2 MB	0 MB/s	0 Mbps	0%	
> Calendar		0%	47.9 MB	0 MB/s	0 Mbps	0%	GPU 1 - 3D

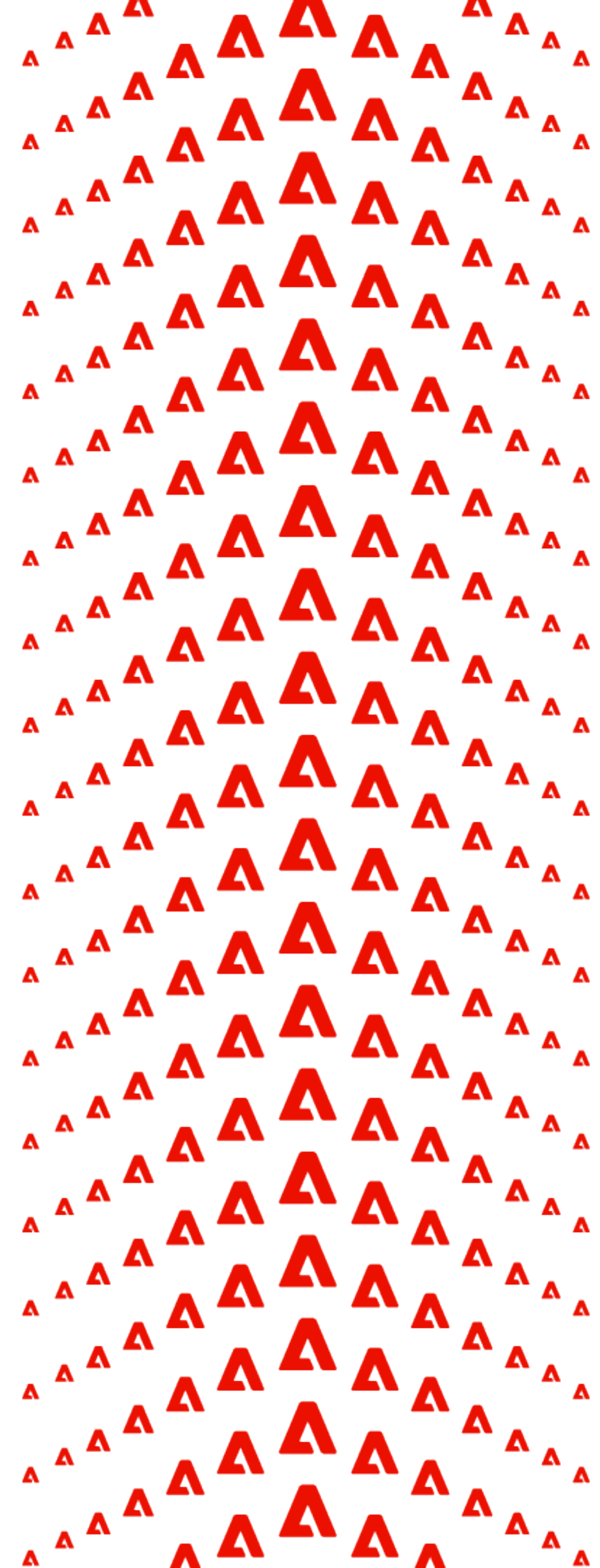
Background Processes

Utilization	Speed	Base speed:	3.10 GHz
11%	3.27 GHz	Sockets:	1
Processes	Threads	Cores:	4
377	5017	Logical processors:	8
	Handles	Virtualization:	Enabled
	275776	L1 cache:	256 KB
Up time		L2 cache:	1.0 MB
7:01:29:19		L3 cache:	8.0 MB

Screen Dimensions vs Memory



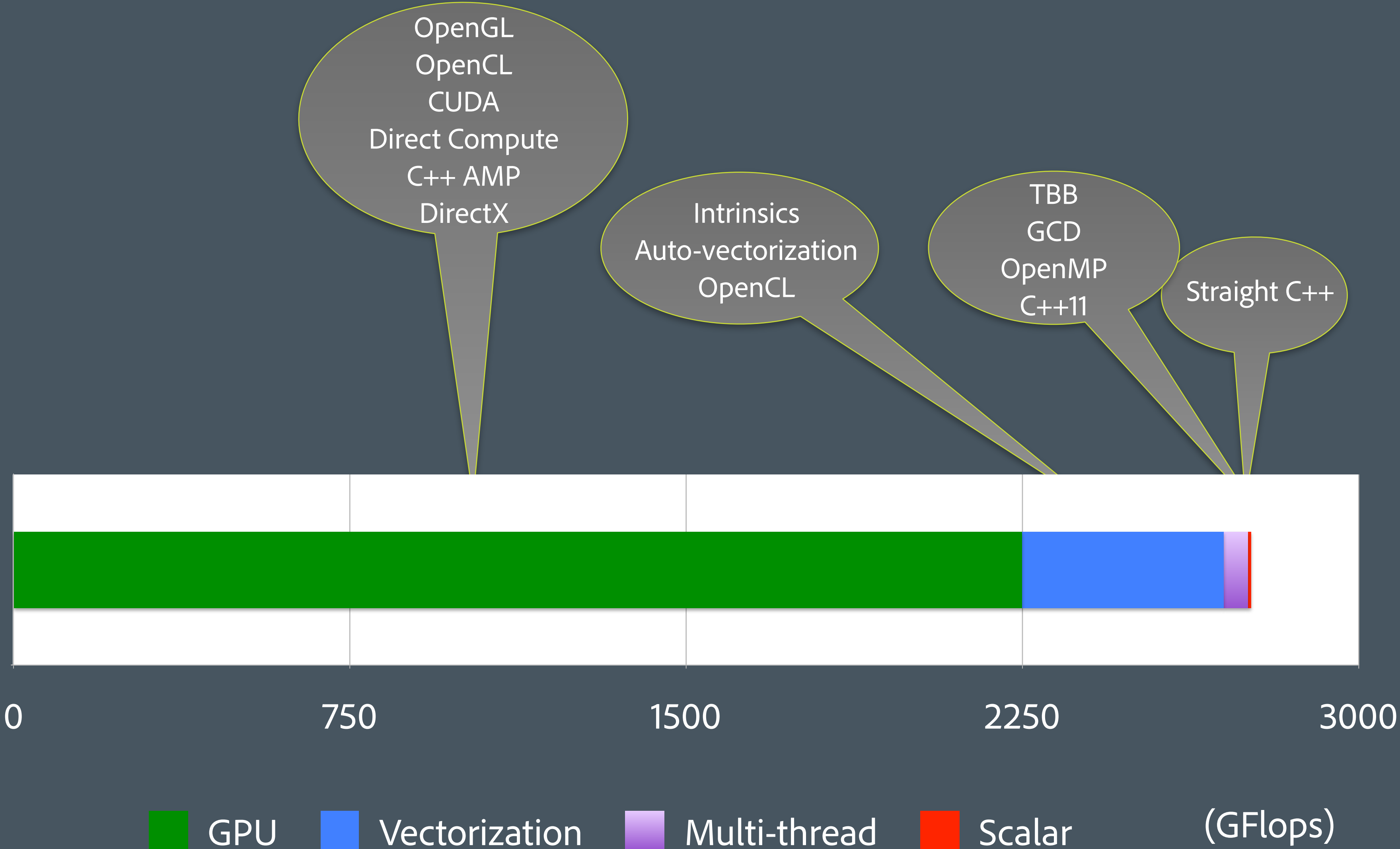
Programming Model



Sand in the Programming Model

- Heap Allocated Objects 200 - 500
 - Lifetime Management - Atomic Ops 30 - 60
 - Indirection & Virtualization 10 - 20
- Threads - Context Switch 10,000 - 1,000,000
 - Dispatch cost 500 - 600
- Arrays of Structures (AoS) 8 - 32
- Raw loops 100x
- JIT compilation and GC 10x

Desktop Compute Power (8-core 3.5GHz Sandy Bridge + AMD Radeon 6950)



Digging Out

- Hardware changes
 - Unified and shared memory
- OS changes
 - Managed cores across processes
 - Hints for thermal, memory, heterogeneous core, and cache utilization
 - Coordinated asynchronous, DMA based IO



Language Changes

- Mutable value semantics
 - <https://www.val-lang.dev/>
- Structured task concurrency model
 - Grain size control
 - Explicit data dependencies for thread affinity
- GPU and SIMD execution model
 - Algorithms and execution abstraction
- Array of structures of arrays (AoSoA) support



About the artist

Daniel Mercadante

American artist and filmmaker Daniel Mercadante creates surreal photographs by painting in camera with a custom-built lighting rig. Inspired by the peace and beauty of the natural world, he shoots multiple long exposures of the same composition, and then animates his images to create meditations on light and nature. Mercadante created this piece using a Canon 5D camera and Contax/Zeiss vintage lens, and then fine-tuning color and exposure in Adobe Lightroom and making final touches to the light path in Adobe Photoshop.

Made with

 Adobe Photoshop

 Adobe Photoshop Lightroom





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