

Programação Paralela: das *threads* aos FPGAs

Introdução

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Roteiro

Abordagem

Paralelismo lógico

Lei de Moore

Paralelismo físico

Top 500

Bem vindo à selva!

Bibliografia

Abordagem

Parallel computing		[hide]
General	Distributed computing · Parallel computing · Massively parallel · Cloud computing · High-performance computing · Multiprocessing · Manycore processor · GPGPU · Computer network · Systolic array	
Levels	Bit · Instruction · Thread · Task · Data · Memory · Loop · Pipeline	
Multithreading	Temporal · Simultaneous (SMT) · Speculative (SpMT) · Preemptive · Cooperative · Clustered Multi-Thread (CMT) · Hardware scout	
Theory	PRAM model · PEM Model · Analysis of parallel algorithms · Amdahl's law · Gustafson's law · Cost efficiency · Karp–Flatt metric · Slowdown · Speedup	
Elements	Process · Thread · Fiber · Instruction window · Array data structure	
Coordination	Multiprocessing · Memory coherency · Cache coherency · Cache invalidation · Barrier · Synchronization · Application checkpointing	
Programming	Stream processing · Dataflow programming · Models (Implicit parallelism · Explicit parallelism · Concurrency) · Non-blocking algorithm	
Hardware	Flynn's taxonomy (SISD · SIMD · SIMT · MISD · MIMD) · Dataflow architecture · Pipelined processor · Superscalar processor · Vector processor · Multiprocessor (symmetric · asymmetric) · Memory (shared · distributed · distributed shared · UMA · NUMA · COMA) · Massively parallel computer · Computer cluster · Grid computer · Hardware acceleration	
APIs	Ateji PX · Boost.Thread · Chapel · HPX · Charm++ · Cilk · Coarray Fortran · CUDA · HIP · Dryad · C++ AMP · Global Arrays · MPI · OpenMP · OpenCL · OpenHMPP · OpenACC · TPL · PLINQ · PVM · POSIX Threads · RaftLib · UPC · TBB · ZPL	
Problems	Automatic parallelization · Deadlock · Livelock · Deterministic algorithm · Embarrassingly parallel · Parallel slowdown · Race condition · Software lockout · Scalability · Starvation	



Category: parallel computing

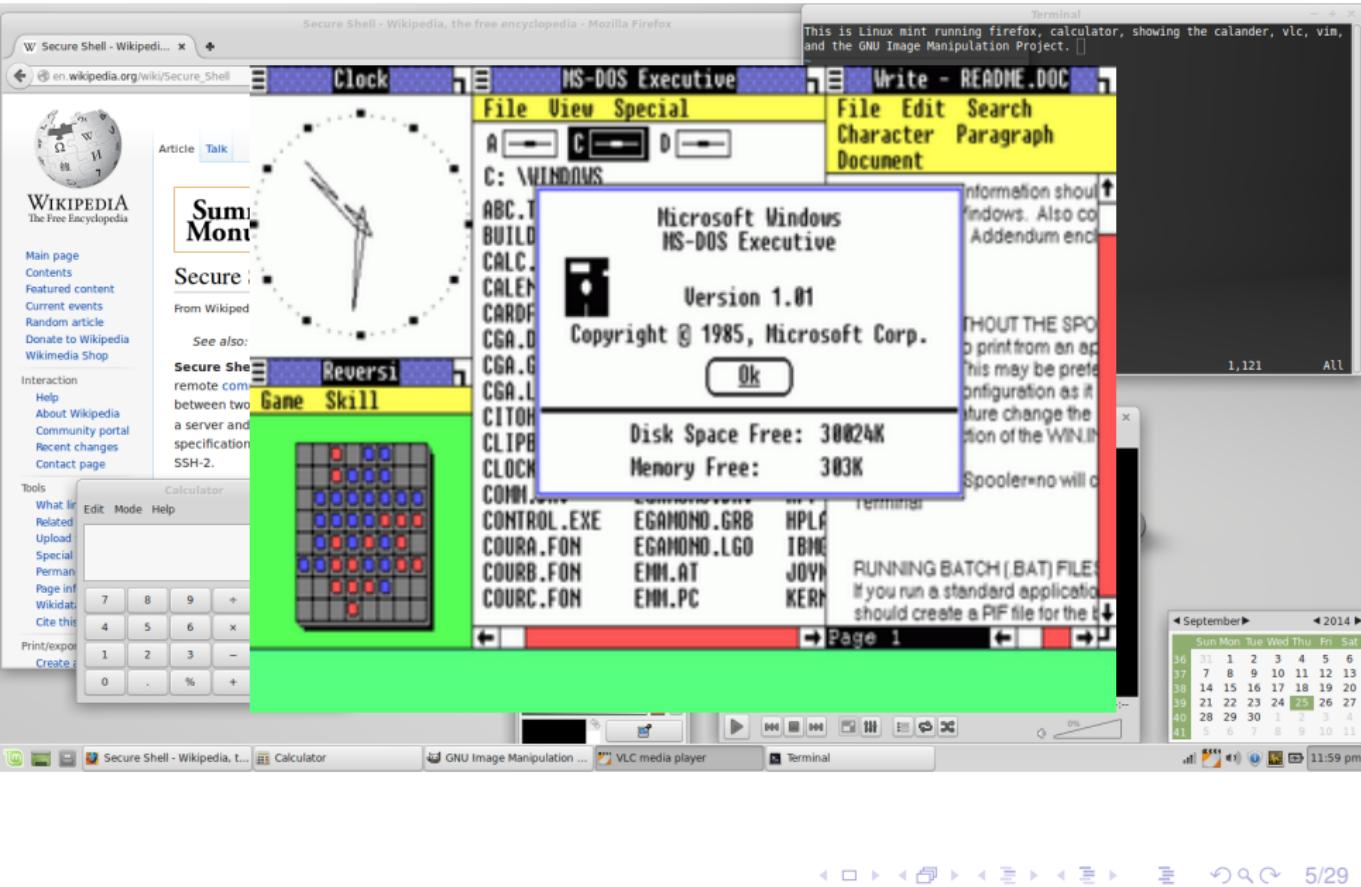


Media related to Parallel computing at Wikimedia Commons

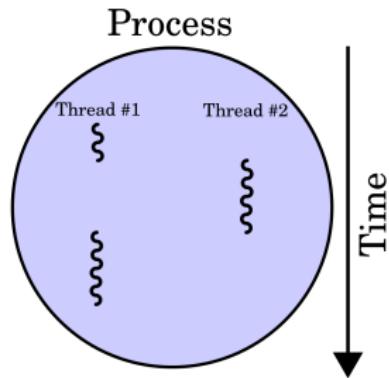
Abordagem

- ▶ Dificuldade de organizar os conceitos;
 - ▶ O paralelismo está presente em diversas granularidades e formas;
 - ▶ A tecnologia disponível hoje não surgiu sequencialmente ao longo do tempo;
 - ▶ Muitas delas não substituiram tecnologias anteriores, mas foram incorporadas aos computadores;
- ▶ Abordagem histórica;
 - ▶ Importante para entender a razão das coisas;
 - ▶ Datas mencionadas (marcos históricos):
 - ▶ Publicação científica;
 - ▶ Uso em primeiros/grandes computadores;
 - ▶ Popularização (desktops, laptops, etc.)

Multitasking



Threads

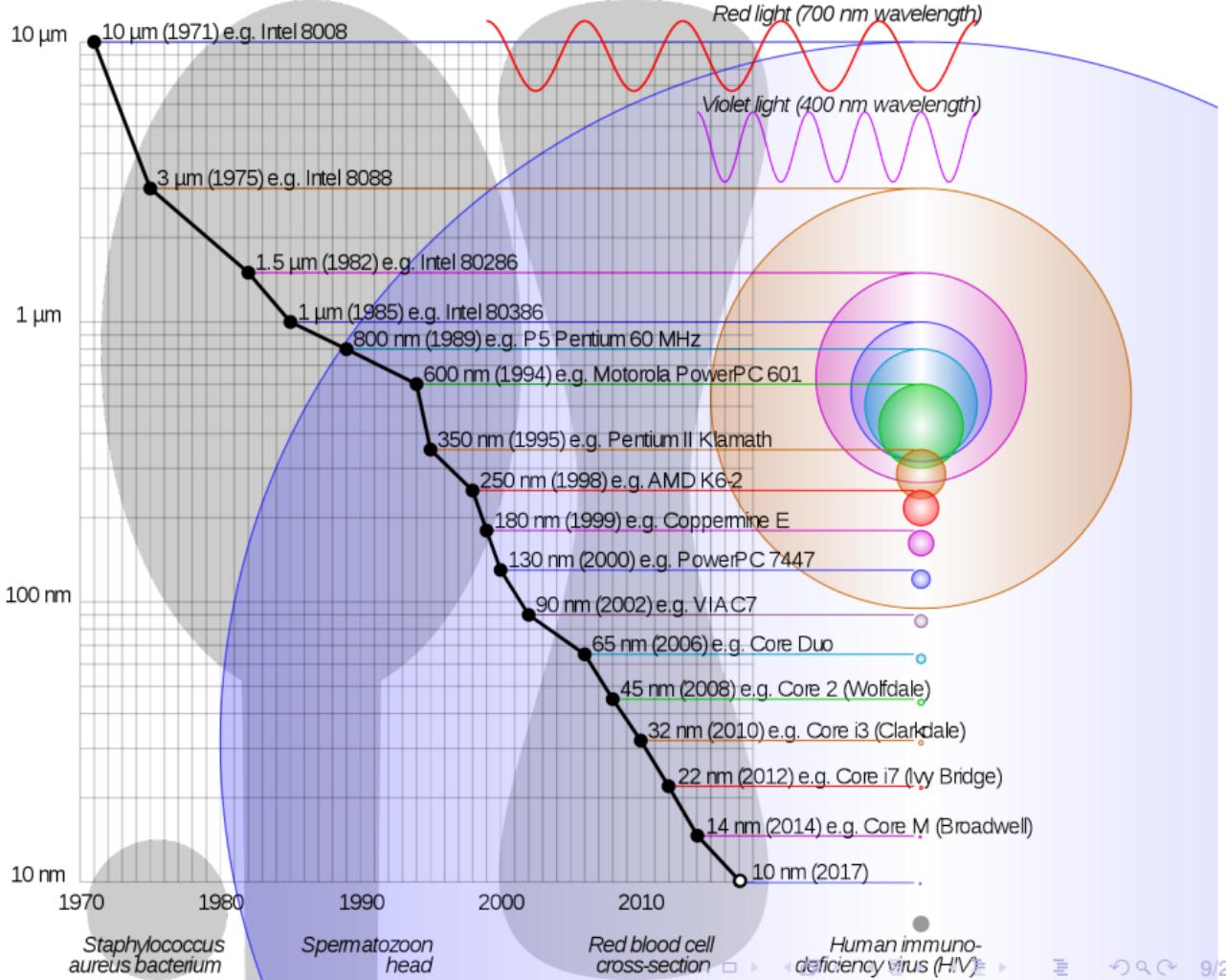


- ▶ Software (Sistema Operacional)
 - ▶ IBM System/360 Operating System
 - ▶ 1967
- ▶ Hardware (Processador)
 - ▶ Intel Pentium 4 (*hyper-threading*)
 - ▶ 2002

Lei de Moore

Normalmente diz que X dobra a cada 18-24 meses, sendo X:

- ▶ Desempenho dos computadores;
- ▶ Frequência dos processadores;
- ▶ O número de transistores por chip;
- ▶ Um dos itens acima, a custo constante.

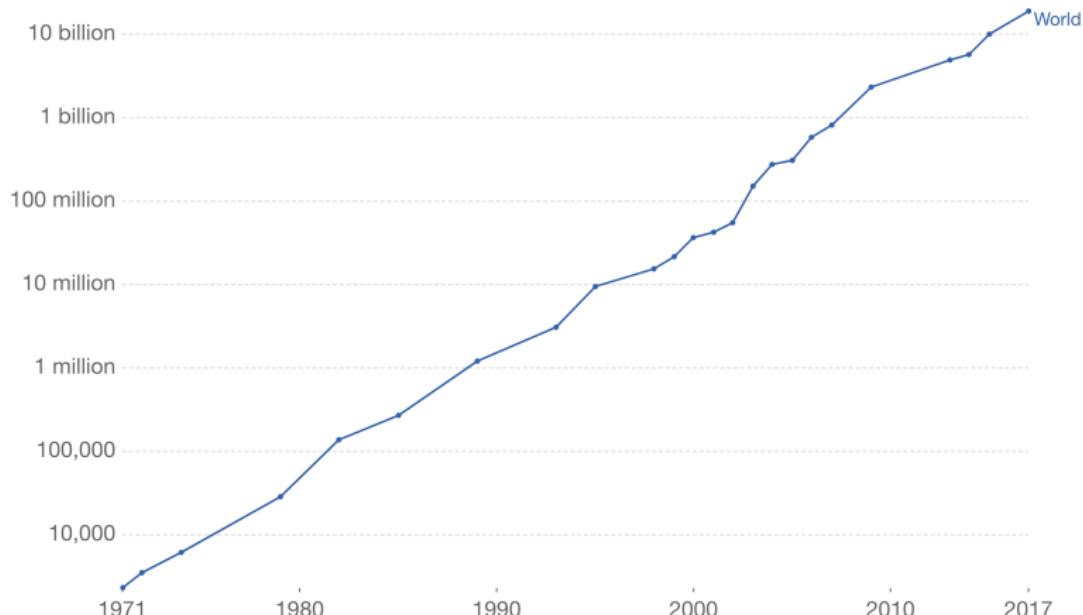


Lei de Moore

Our World
in Data

Moore's Law: Transistors per microprocessor

Number of transistors which fit into a microprocessor. This relationship was famously related to Moore's Law, which was the observation that the number of transistors in a dense integrated circuit doubles approximately every two years.

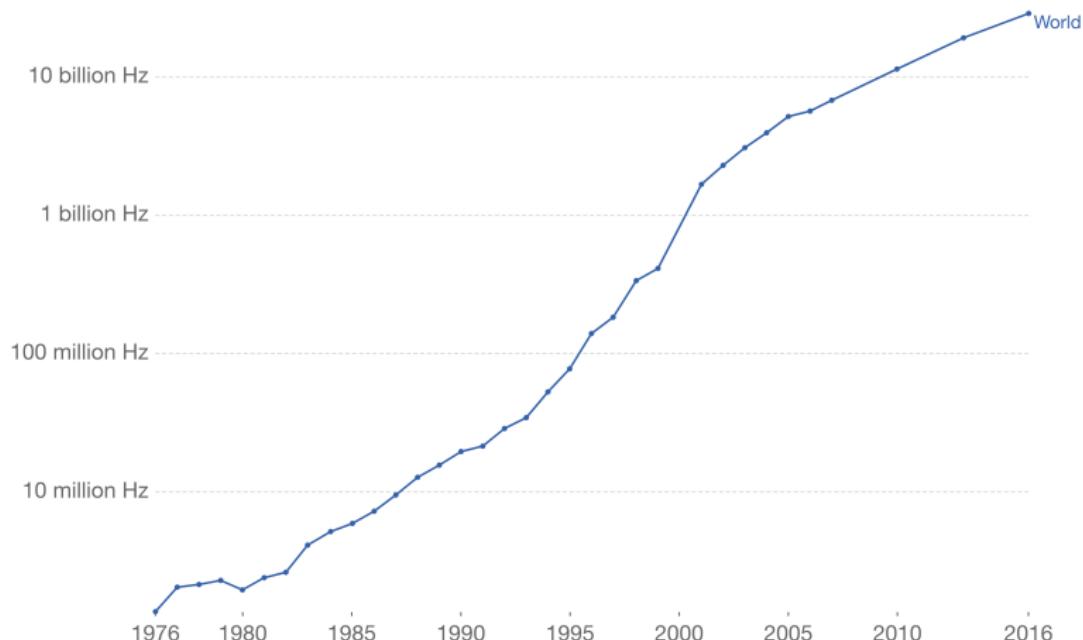


Source: Karl Rupp. 40 Years of Microprocessor Trend Data.

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Microprocessor clock speed, 1976 to 2016

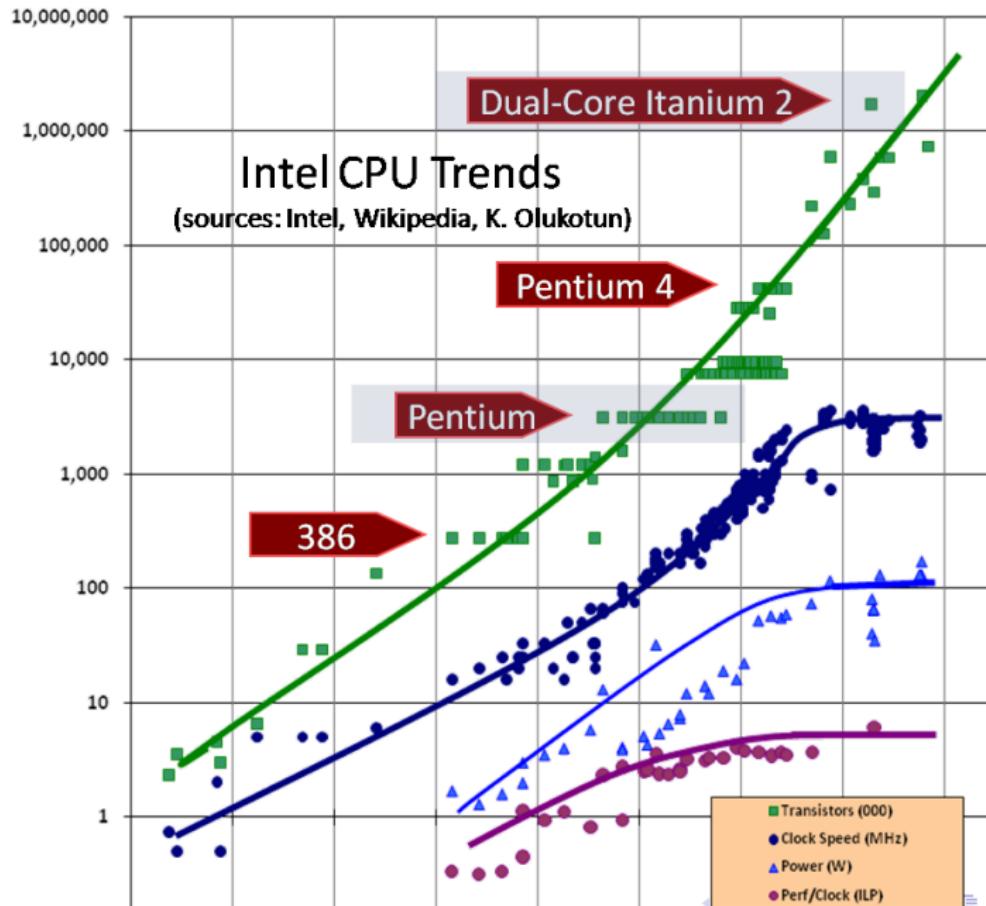
Microprocessor clock speed measures the number of pulses per second generated by an oscillator that sets the tempo for the processor. It is measured in hertz (pulses per second).



Source: Ray Kurzweil (2005, updated to 2016). *The Singularity Is Near: When Humans Transcend Biology*.

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Lei de Moore



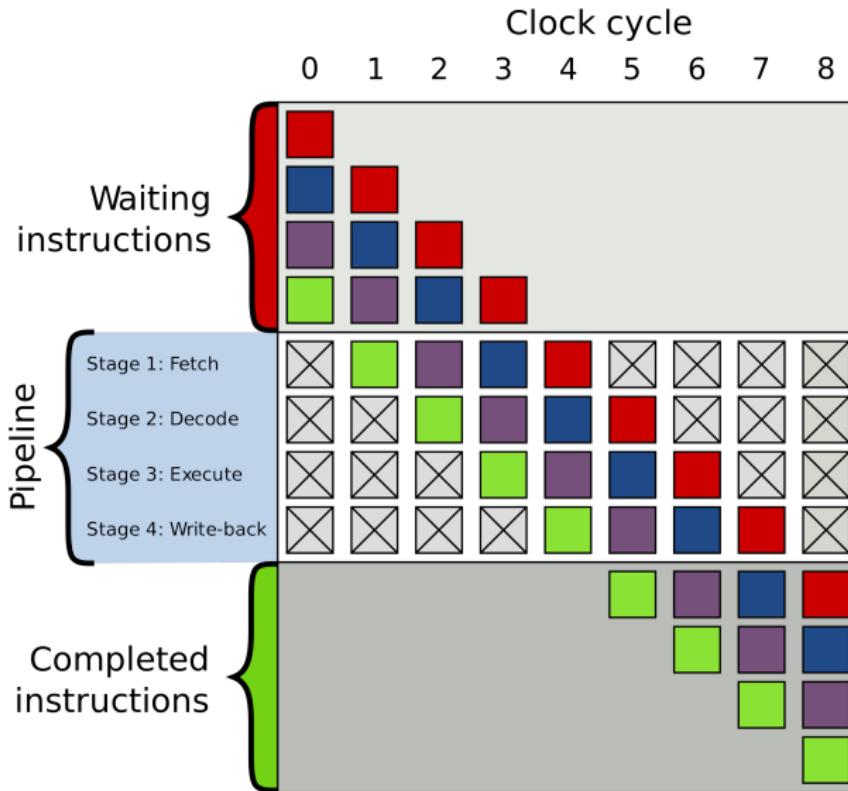
Formas de exploração de paralelismo

- ▶ Diversas formas de paralelismo foram surgindo ao longo do tempo;
- ▶ Algumas delas são transparentes [ou quase] para o desenvolvedor;
- ▶ Outras precisam ser exploradas explicitamente;
- ▶ Vamos abordar as mais comuns/relevantes atualmente;

Instruction Level Parallelism (ILP)

- ▶ *Pipelining*
- ▶ *Very Long Instruction Word (VLIW)*
- ▶ *Superscalar*

Pipelining



Pipelining

- ▶ ILLIAC II (University of Illinois), 1958
- ▶ IBM 7030 Stretch, 1961¹
- ▶ Amdahl Co. 470 series, 1976

¹Computador mais rápido do mundo

Very Long Instruction Word (VLIW)

- ▶ Josh Fisher (Yale University), 1983
- ▶ Intel, Itanium (Merced), 2001

Superscalar

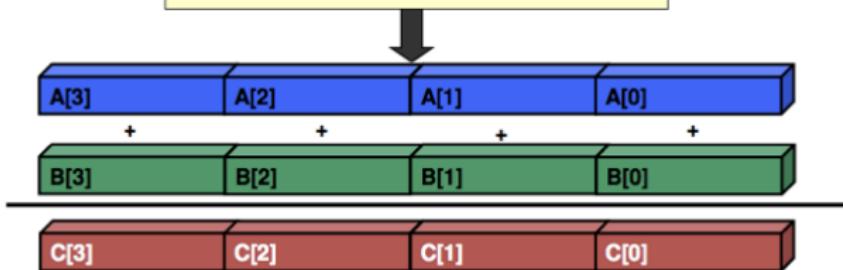
- ▶ Seymour Cray's CDC 6600, 1966
- ▶ Motorola MC88100, 1988
- ▶ Intel i960CA, 1989
- ▶ AMD 29050, 1990

Data Parallelism

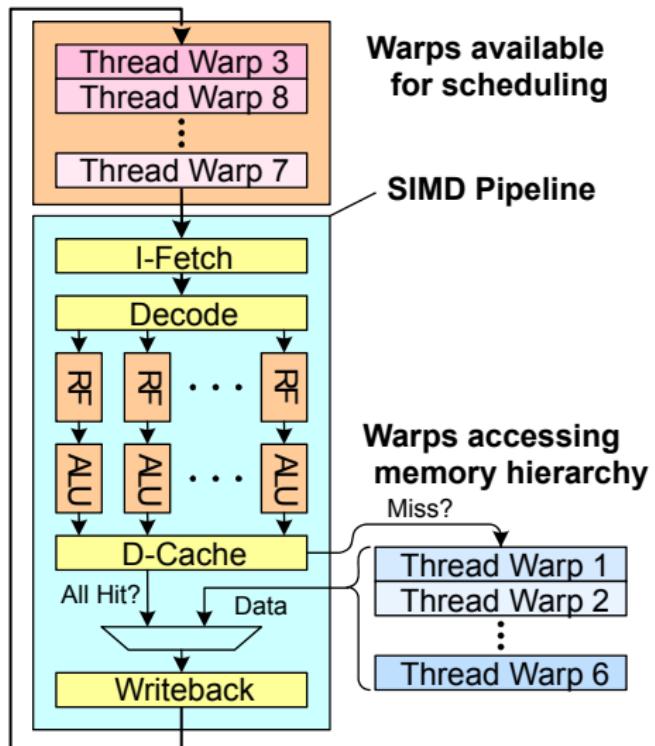
- ▶ *Single Instruction Multiple Data (SIMD)*
- ▶ *Single Instruction Multiple Thread (SIMT)*

Single Instruction Multiple Data (SIMD) 1966/1996

```
for (i=0; i<MAX; i++)  
    c[i]=a[i]+b[i];
```

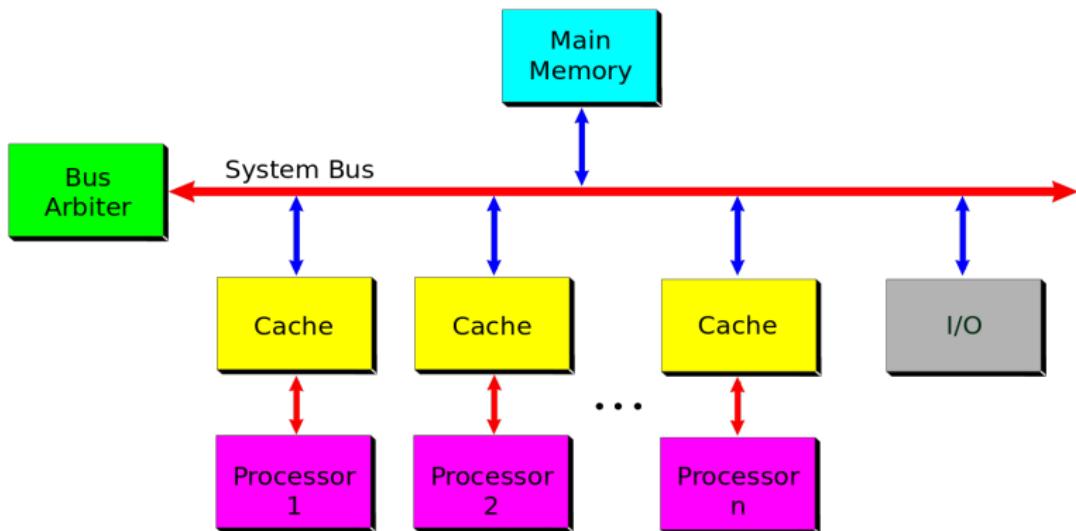


Single Instruction Multiple Thread (SIMT) 2008



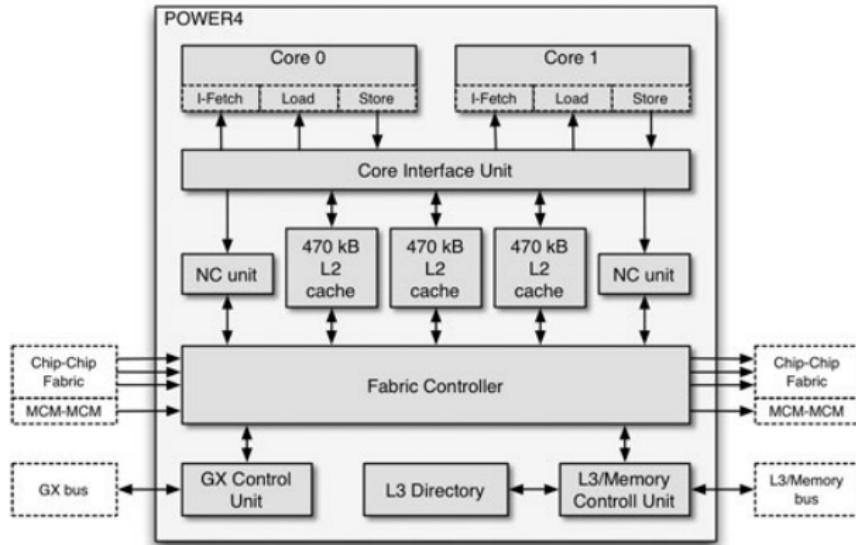
Symmetric MultiProcessing (SMP) - 1961/2006

SMP - Symmetric Multiprocessor System

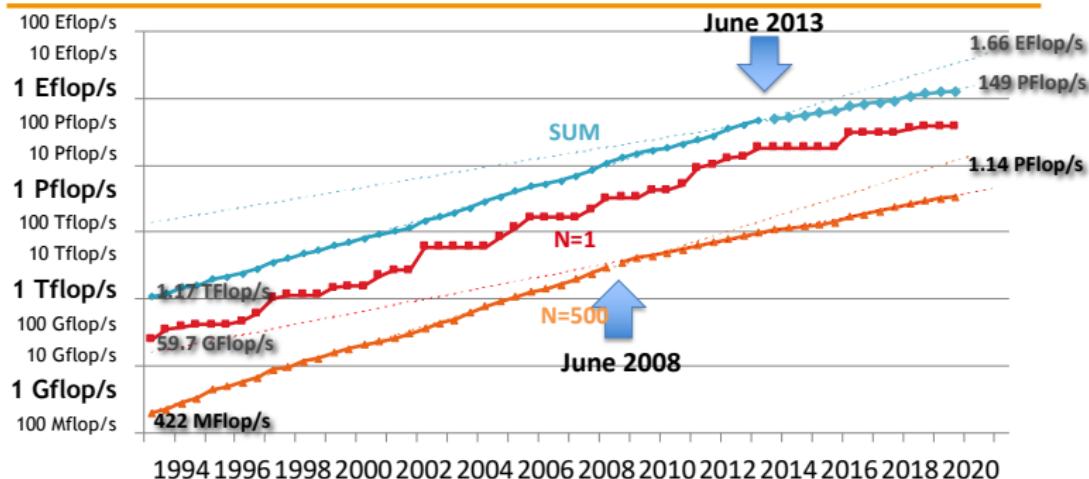


By Ferruccio Zullen - Milan, Italy

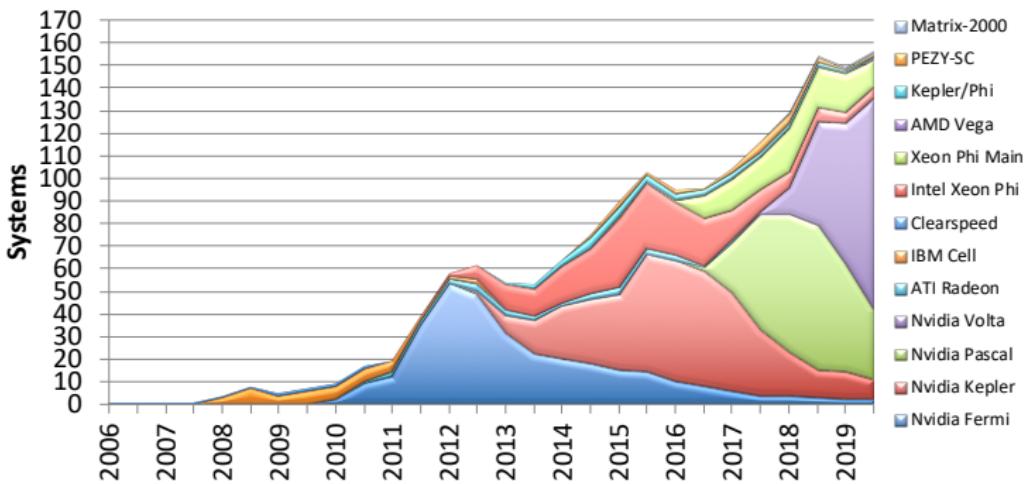
Multi-core - 2001/2005



PERFORMANCE DEVELOPMENT

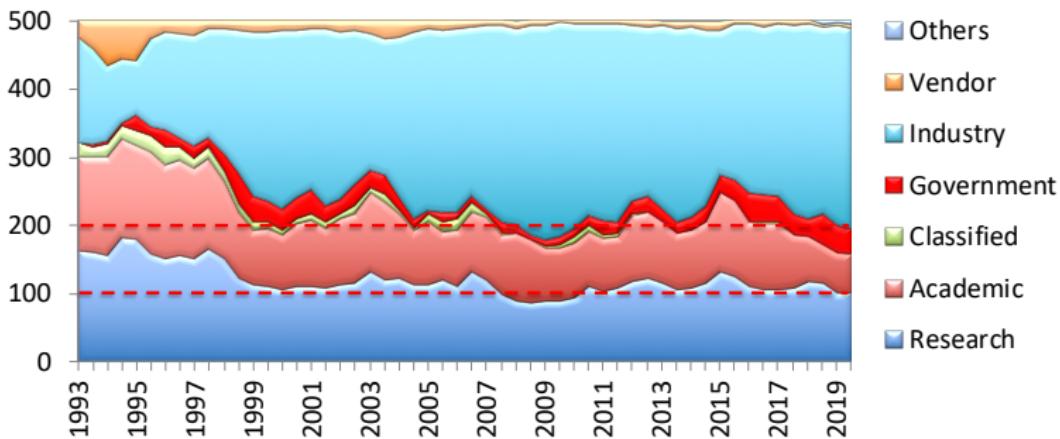


ACCELERATORS

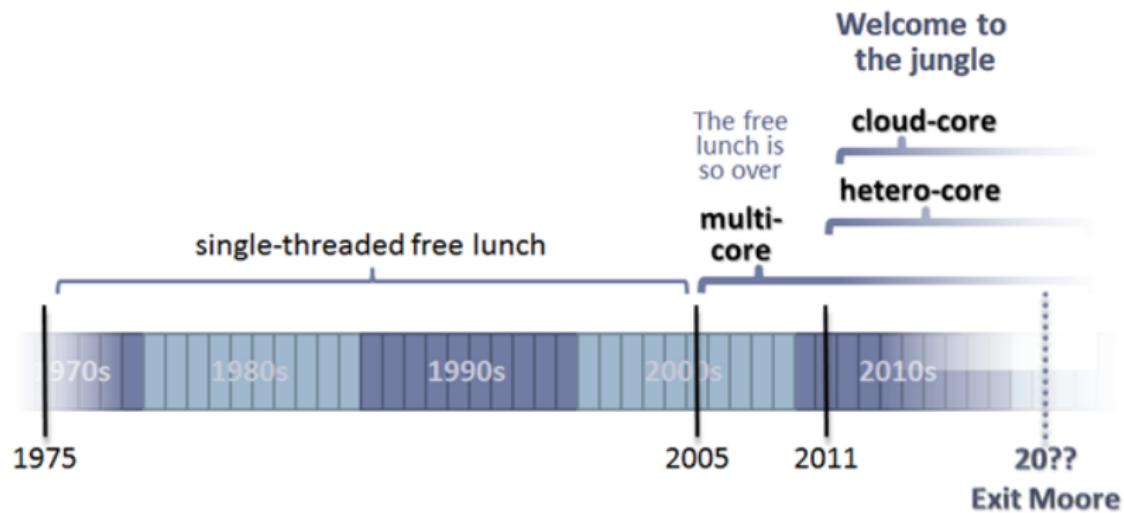




MARKET SEGMENTS



Bem vindo à selva!



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- ▶ The History of the Development of Parallel Computing
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- ▶ Max Roser and Hannah Ritchie, Technological Progress.
- ▶ Linux and symmetric multiprocessing
- ▶ Flynn, Michael J. "Some computer organizations and their effectiveness." IEEE transactions on computers, 1972
- ▶ **Introduction to Parallel Computing, Overview**
- ▶ **Herb Sutter, Welcome to the Jungle - Or, A Heterogeneous Supercomputer in Every Pocket**