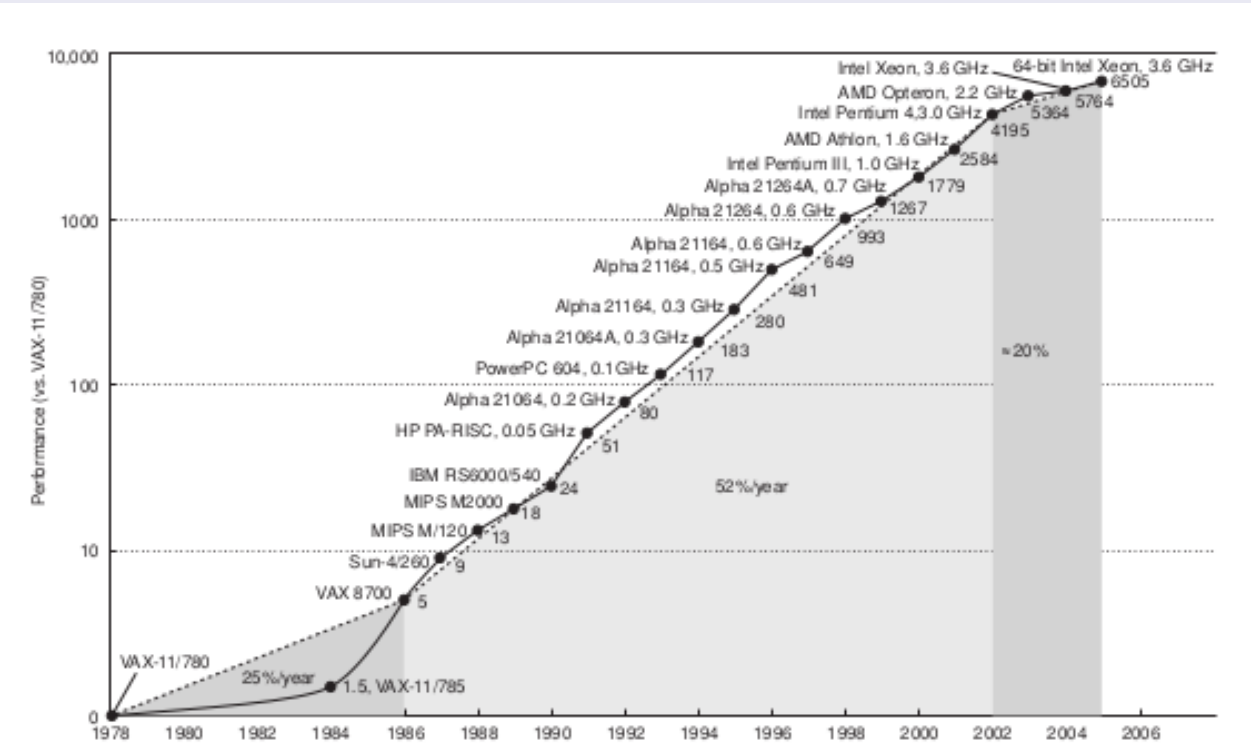
Intéraction Logiciel Architecture

Les performances et leur mesure

Henri-Pierre Charles Henri-Pierre.Charles@cea.fr &
Frédéric Rousseau Frederic.Rousseau@imag.fr

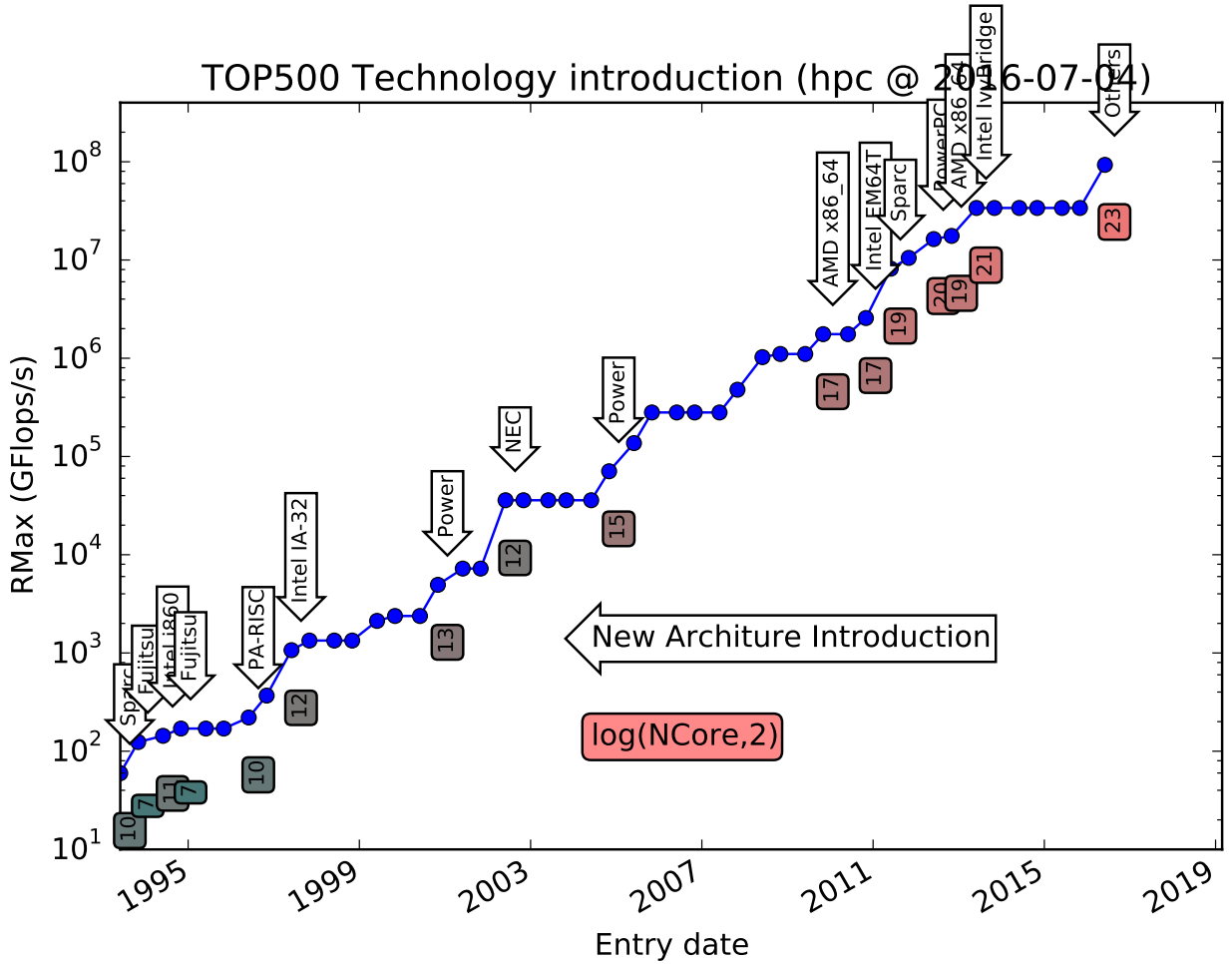
Metrics Moore

La loi de Moore



Growth in processor performance since the mid-1980s. This chart plots performance relative to the VAX 11/780 as measured by the SPECint benchmarks [Hennessy]

Metrics Top500



Lien entre l'introduction d'une nouvelle technologie et son impact sur les performances

1. Motivation
   - Metrics Moore
   - Metrics Top500
2. Pourquoi
   - Metrics How to Measure Performance ?
   - Vocabulaire : Cycle par seconds / Flops
   - Vocabulaire Peak / Sustained
   - Vocabulaire Lois
   - Vocabulaire Speedup
   - Amdahl2
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   - Metrics Roofline
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   - Comment : PerfCounter
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   - Comment gdb
   - Comment qemu

Metrics How to Measure Performance ?

What scale ?

- Application level (TPS, Frame/s, .../)
- Run to completion
- Method level
- Instruction level

Tools

- Wall clock
- `gettimeofday`
- Performance counters

Full application or function call ?

- Cold start / warmup
- Statistic / multiple calls
- How many calls

Vocabulaire : Cycle par seconds / Flops

Units

Mips	Million operation per second
Flops	Floating point operation per second `http://www.top500.org`
Flops/Watt	Floating point operation per watt per second `http://www.green500.org`
IPC	: Instructions per Cycle

How to mesure

- Analytique (wall clock)
- Instrumentation
  - "Portable" (`gettimeofday()`)
  - Hardware (hardware performance counter)

Vocabulaire Peak / Sustained

Notions

Peak performance : maximal theoretical performance, assuming no bubble

Sustain performance : real acheived performance, on a real benchmark

Cost

- What is the percentage you're ready to lose ? 90% 95% ?
- How many are you ready to pay (time, money) to minimise this loss ?

`http://www.top500.org`

Vocabulaire Lois

Obey the law !

- Moore `http://en.wikipedia.org/wiki/Moore's_law`
- Amdahl `http://en.wikipedia.org/wiki/Amdahl's_law`
- Memory bound `http://en.wikipedia.org/wiki/IO_bound`
- CPU bound `http://en.wikipedia.org/wiki/CPU_bound`

Vocabulaire Speedup

Notion

Speedup $S = 100 * \frac{T_{seq}}{T_{opt}}$

Can be between

- 1 and N processor
- 1 and vectorized
- non optimized versus optimized version

Mesure Quality what are the execution conditions : data set, computer workload, reproducibly, ...

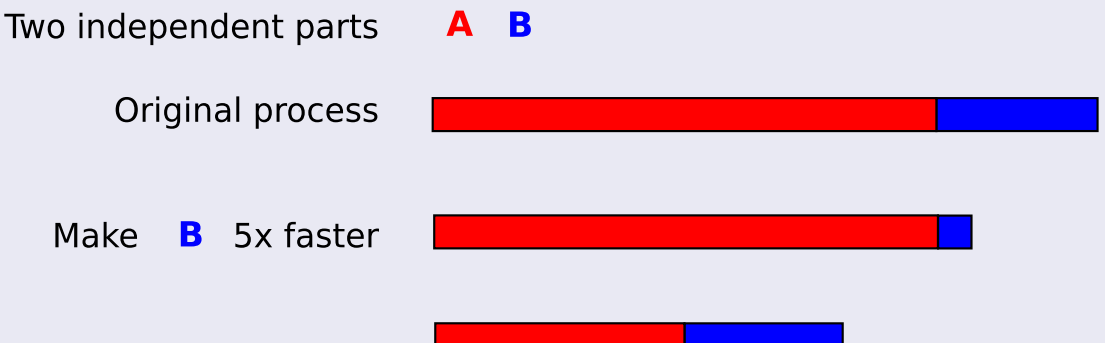
Computer science has to use “human science” tools & methodology

Amdahl2

Argumentation

Assume that a task has two independent parts, A and B. B takes roughly 25% of the time of the whole computation. By working very hard, one may be able to make this part 5 times faster, but this only reduces the time for the whole computation by a little. In contrast, one may need to perform less work to make part A be twice as fast. This will make the computation much faster than by optimizing part B, even though B's speed-up is greater by ratio, (5x versus 2x)

Illustration

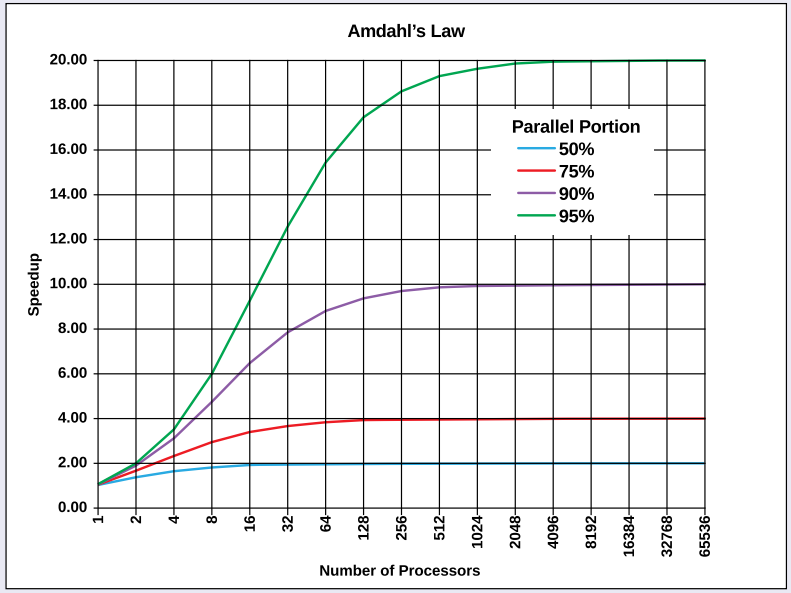


Vocabulaire Amdahl

Argumentation

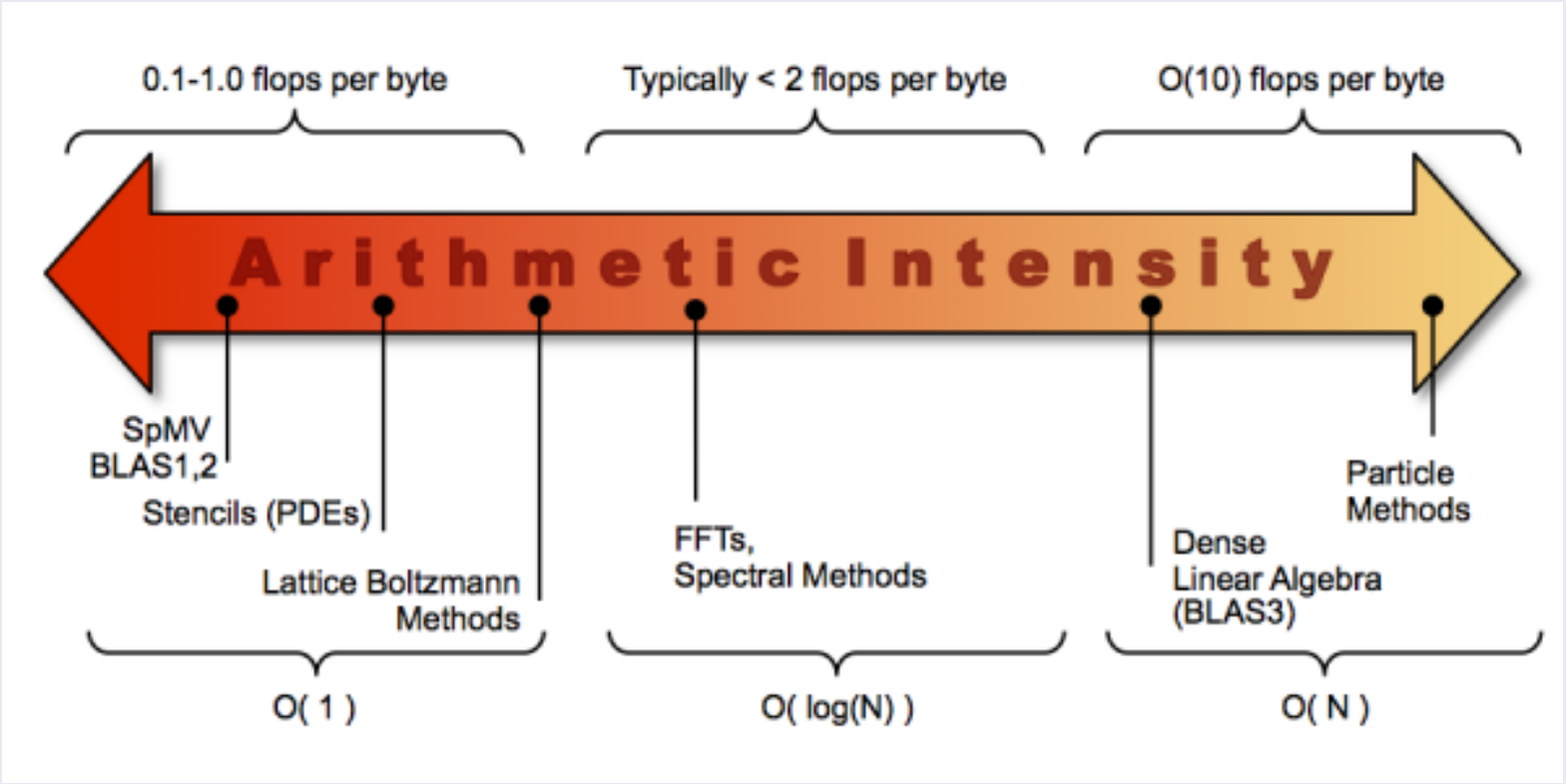
The speedup of a program using multiple processors in parallel computing is limited by the sequential fraction of the program. For example, if 95% of the program can be parallelized, the theoretical maximum speedup using parallel computing would be 20x as shown in the diagram, no matter how many processors are used.

Illustration



Metrics Roofline model

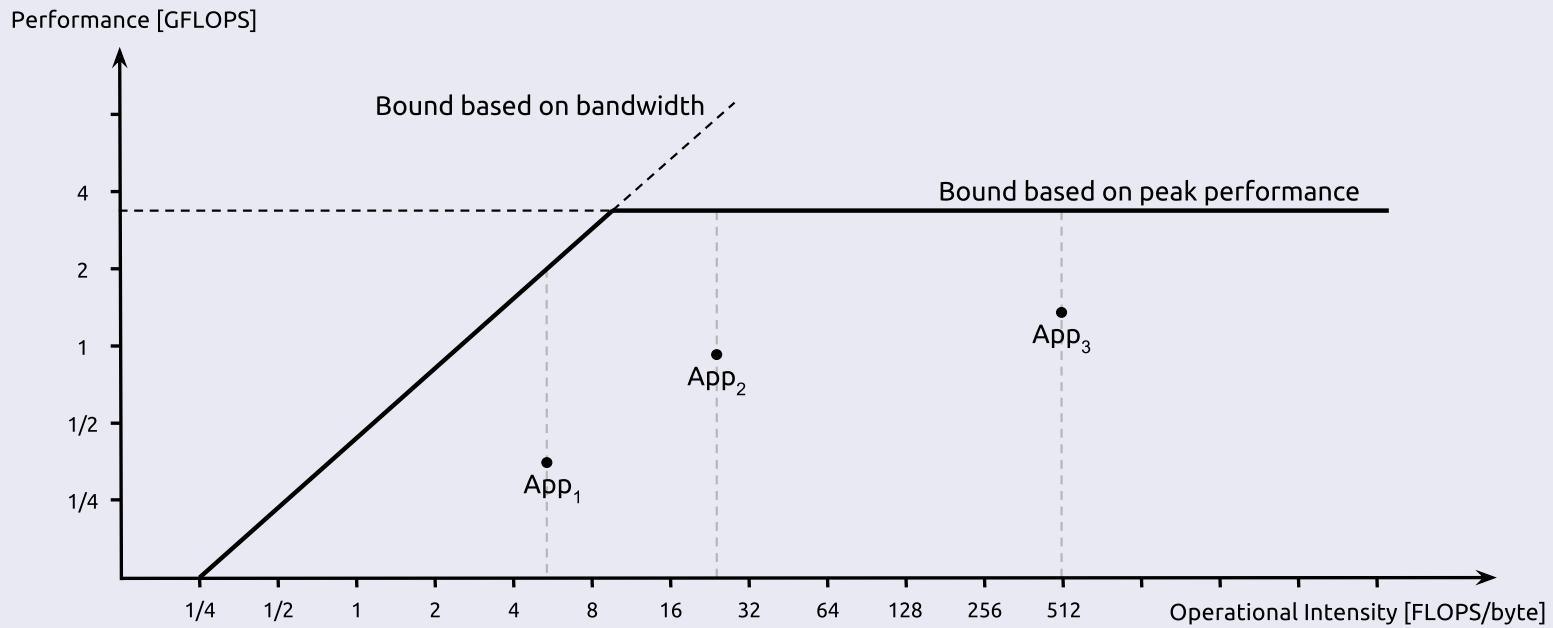
Intensité arthmétique



(From `https://crd.lbl.gov/departments/computer-science/PAR/research/roofline/`)

Metrics Roofline

Arithmetic intensity versus performance



https://en.wikipedia.org/wiki/Roofline_model

Comment Outillage

Outillage pour la performance

- HW related
  - gprof
  - gdb
- Simulation
  - Performance counters
  - JTAG
- Analytical
  - Statical analysis

Rappels Static Compilation chain

Static compilation (on C language) :

1. Preprocessor (all # stuff : rewriting) `cc -E`
2. Compilation (from C to textual assembly) `cc -S`
3. Assembly (from textual asm to binary asm) `cc -c`
4. Executable (binary + dynamic library)

Optional

- Profiling : Compile (use `-pg`) produce `File` ; Run `File` ; Use `gprof`
- `cc -da` dump all intermediate representation

(Use gcc -v to see all the steps)
Don't stop at static time (Operating system + processor) : Load in memory, dynamic linking ; Branch resolution ; Cache warmup

Comment gprof

Argumentation

- Compile using `-pg` option `gcc -pg -o prog prog.c`, add information at the begin / end of each function
- Run the code `./prog` (create the `gmon.out` file)
- Run gprof `gprof prog`
- Read report !

Pitfalls

- Warning with `-O3` interaction !
- Use `-O0` as first pass
- Use `-O3` for real

Limitations

- Not fine grain
- Measure perturbation

Comment : PerfCounter

Performance counter from HW

- Simple one : `cycle counter`
- `RAT_STALLS` Counts the number of cycles during which execution stalled due to several reason
- L2, L3 cache access ...

Tools

- Intel tools : `http://www.intel.com/software/pcm`
- Papi : `http://icl.cs.utk.edu/papi`
- Tiptop from Inria : `http://tiptop.gforge.inria.fr/`

Limitations

- Complicated to understand / analyse
- No real portable library

Comment JTAG

Argumentation

-

Illustration

Comment gdb

Argumentation

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Illustration

Comment qemu

Argumentation

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Illustration