High Performance Computing: Towards Better Performance Predictions and Experiments

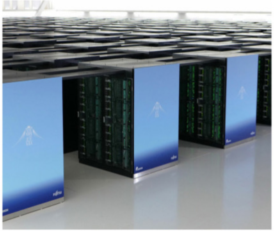
Tom Cornebize

2 June 2021, PhD defense

No science without computing

Arithmomètre (1851)

ENIAC (1945)



Fugaku (2021)

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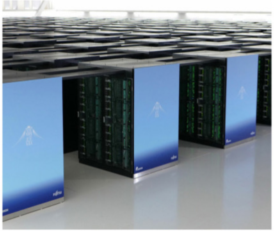

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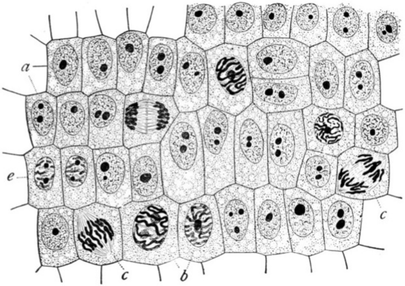
Last decades:

- Exponential performance improvements (e.g. sequencing an entire human genome costed $100,000,000 in 2001, $1000 now)
- At the price of complexity (both software and hardware)

Experimental study of computer performance



Similar to natural sciences

Complexity $\Rightarrow$ Variability and Opacity

$\Rightarrow$ No perfect model

$\Rightarrow$ Need for experiments

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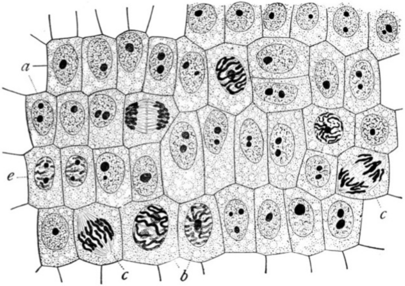

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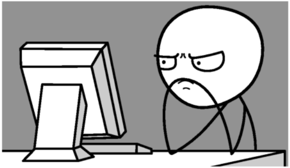
Empirical studies can be carried in reality or in simulation

Typical Performance Evaluation Questions (Given my application and a supercomputer)



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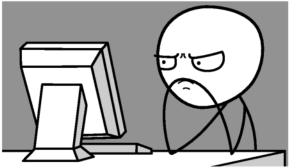

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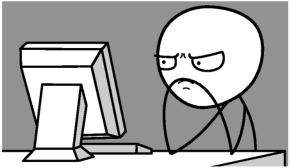

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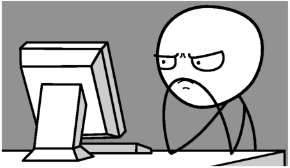

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Holy Grail: Predictive Simulation on a "Laptop"

Capture the **whole application** and **platform complexity**

Initial goal: predict the performance of a parallel application

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Thesis contributions (towards this goal)

- Case study: High Performance Linpack (HPL)
- Extensive (in)validation, comparing simulations with reality
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Performance prediction through simulation

Full reimplementation of MPI on top of SIMGRID

- C/C++/F77/F90 codes run unmodified out of the box
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Emulation: how?

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Contribution: Skip the expensive computations (mostly `dgemm`) and replace them by performance models

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Validations of SMPI before this thesis: simple applications without any high performance tricks

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Contribution: predict accurately the performance of HPL

- Computations and communication overlap
- More representative of some HPC workloads
- Well established, used for the Top500

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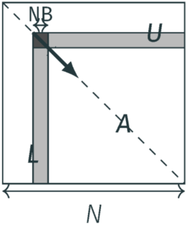

Allocate and initialize A

for $k = N$ ***to*** 0 ***step*** NB **do**

  Allocate the panel

  Factor the panel

  Broadcast the panel

  Update the sub-matrix

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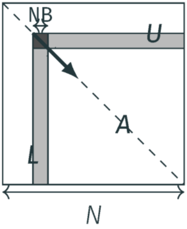

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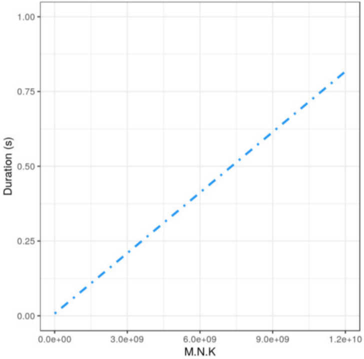
Tuning parameters

- Broadcast algorithm
- Block size
- Process grid
- etc.

Hundreds of combinations

MODELING COMMPUTATIONS

$$\texttt{dgemm}(M, N, K) = \alpha.M.N.K$$



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