High Performance Computing: Towards Better Performance Predictions and Experiments

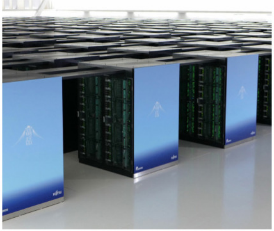
Tom Cornebize

2 June 2021, PhD defense

Université Grenoble Alpes

Arithmomètre (1851)

ENIAC (1945)



Fugaku (2021)

NO SCIENCE WITHOUT COMPUTING

Arithmomètre (1851)

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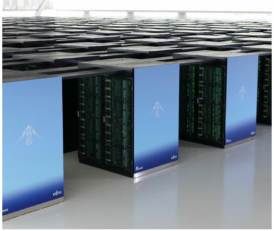

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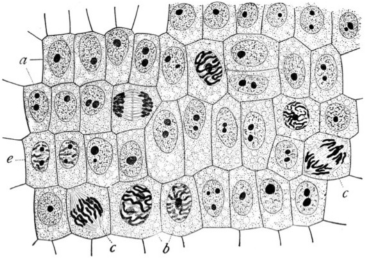
Last decades:

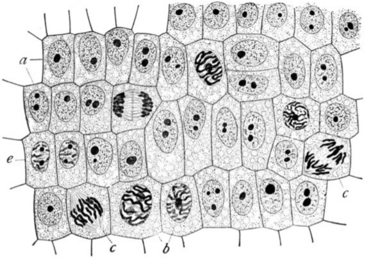
- Exponential performance improvements (e.g. sequencing an entire human genome costed $100,000,000 in 2001, $1000 now)
- At the price of complexity (both software and hardware)



Similar to natural sciences

Complexity

- ⇒ Variability and Opacity
- ⇒ No perfect model
- ⇒ Need for experiments



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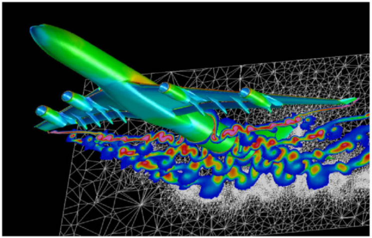
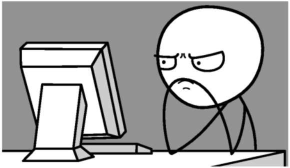
Empirical studies can be carried in reality or in simulation



Context

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



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  - How many nodes?
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  - Which parameters?

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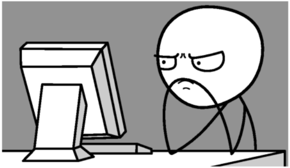

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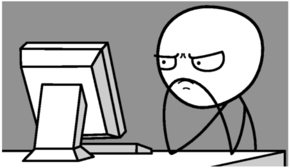

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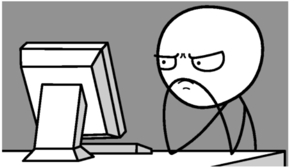

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Holy Grail: Predictive Simulation on a “Laptop”

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
- Demonstrate it is possible to predict faithfully the behavior of complex parallel applications
- Modeling correctly the platform variability is key

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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
- Simply replace mpicc/mpirun by smpicc/smpirun

Sim(Em)ulation: The SMPI Approach

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- Application runs for real on a laptop
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- Performance model for the target platform

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

Quick word on HPL

- Computations and communication overlap (custom collectives)
- More representative of some HPC applications
- Well established, used for the Top500

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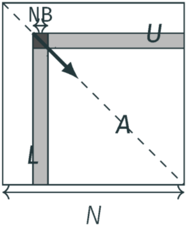

Allocate and initialize A
for $k = N$ ***to*** 0 ***step*** NB **do**
    Allocate the panel
    Factor the panel
    Broadcast the panel
    Update the sub-matrix

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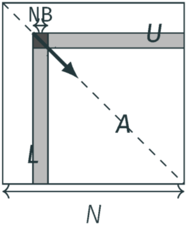

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- Block size
- Broadcast algorithm
- etc.

Hundreds of combinations

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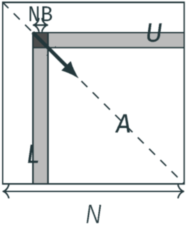

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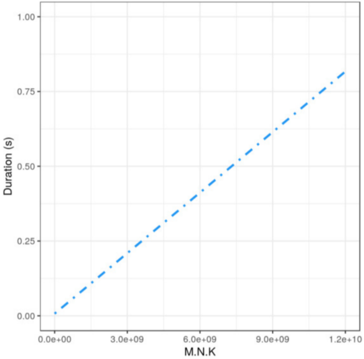
Contribution: Skip the expensive computations (mostly **dgemm**) and replace them by performance models

Modeling Commputations

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



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