

# HIGH PERFORMANCE COMPUTING: TOWARDS BETTER PERFORMANCE PREDICTIONS AND EXPERIMENTS

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Tom Cornebize

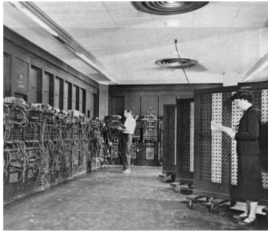
2 June 2021, PhD defense



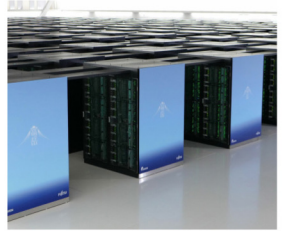
# NO SCIENCE WITHOUT COMPUTING



Arithmomètre (1851)



ENIAC (1945)



Fugaku (2021)

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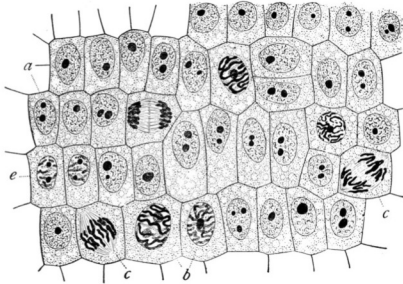


Fugaku (2021)

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



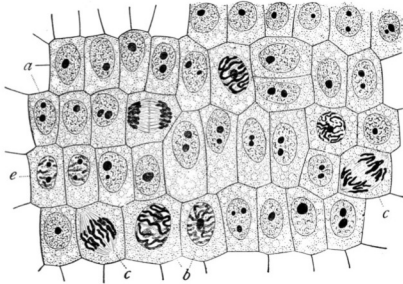
Similar to natural sciences

Complexity  $\Rightarrow$  Variability and Opacity

$\Rightarrow$  No perfect model

$\Rightarrow$  Need for **experiments**

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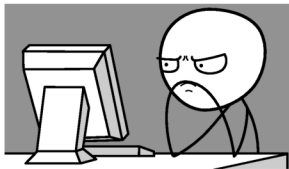
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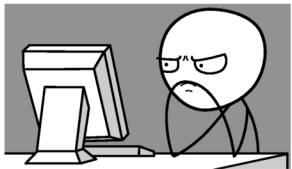
Empirical studies can be carried in **reality** or in **simulation**

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- **Before** running
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## Holy Grail: Predictive Simulation on a “Laptop”

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

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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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- Experiment methodology, to bias or not to bias
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# PERFORMANCE PREDICTION THROUGH SIMULATION

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# SIM(EM)ULATION: THE SMPI APPROACH



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



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

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- Computations and communication overlap (custom collectives)
- More representative of some HPC applications
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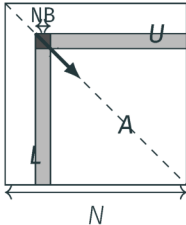


Allocate and initialize  $A$   
**for**  $k = N$  **to**  $0$  **step**  $NB$  **do**  
    Allocate the panel  
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- Block size
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- etc.

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

# MODELING COMPUTATIONS

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