

# HIGH PERFORMANCE COMPUTING: TOWARDS BETTER PERFORMANCE PREDICTIONS AND EXPERIMENTS

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Tom Cornebize

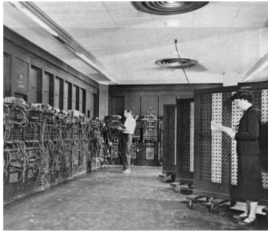
2 June 2021, PhD defense



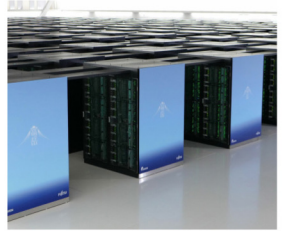
# NO SCIENCE WITHOUT COMPUTING



Arithmomètre (1851)



ENIAC (1945)



Fugaku (2021)

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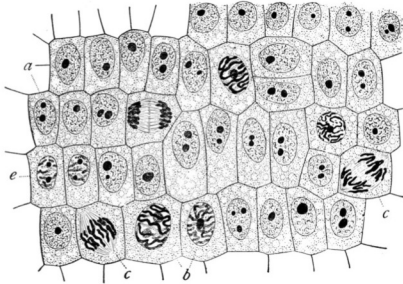


Fugaku (2021)

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



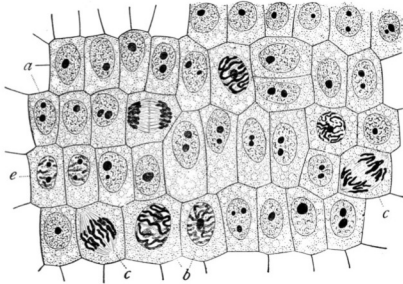
Similar to natural sciences

Complexity  $\Rightarrow$  Variability and Opacity

$\Rightarrow$  No perfect model

$\Rightarrow$  Need for **experiments**

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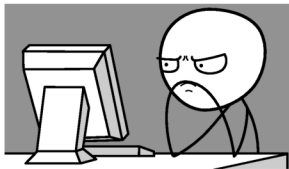
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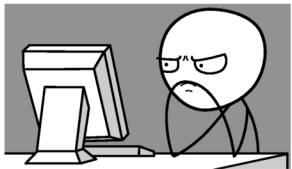
Empirical studies can be carried in **reality** or in **simulation**

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- **Before** running
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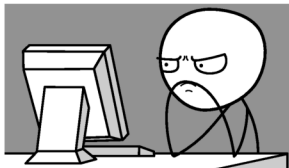


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## Holy Grail: Predictive Simulation on a “Laptop”

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

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

## QUICK WORD ON HPL

Contribution: predict accurately the performance of HPL



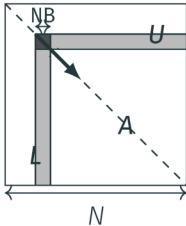
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- More representative of some HPC applications
- Well established, used for the Top500

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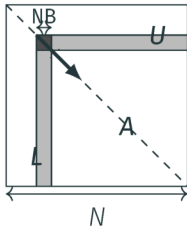
Allocate and initialize  $A$   
**for**  $k = N$  **to**  $0$  **step**  $NB$  **do**  
    Allocate the panel  
    Factor the panel  
    Broadcast the panel  
    Update the sub-matrix

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

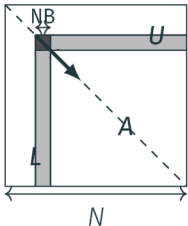
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**Contribution:** Skip the expensive computations (mostly **dgemm**) and replace them by performance models

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