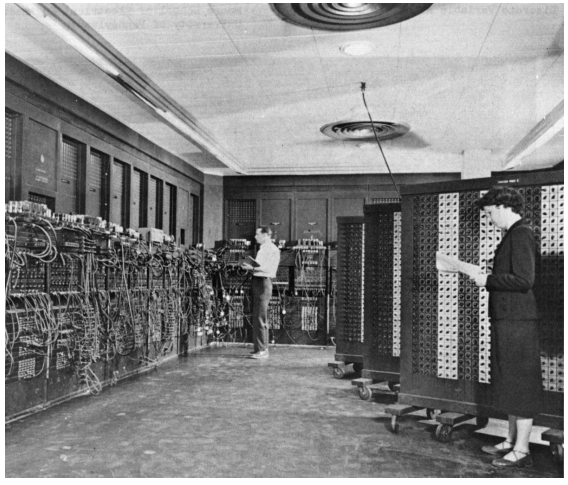
High Performance Computing: Towards Better Performance Predictions and Experiments

Tom Cornebize

2 June 2021, PhD defense

No science without computing

Arithmomètre (1851)



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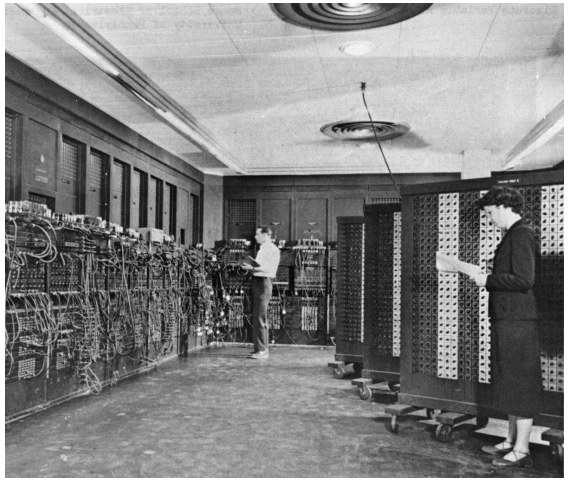

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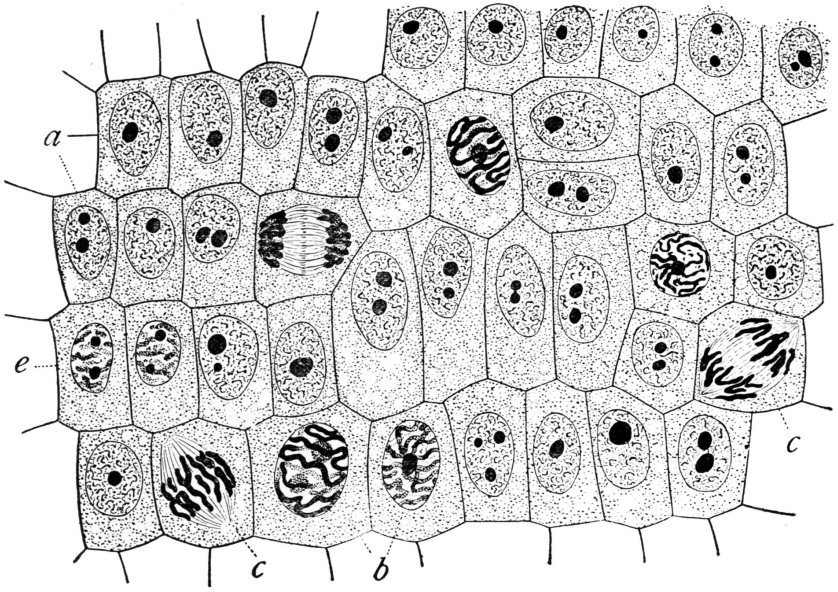
Last decades:

- 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)

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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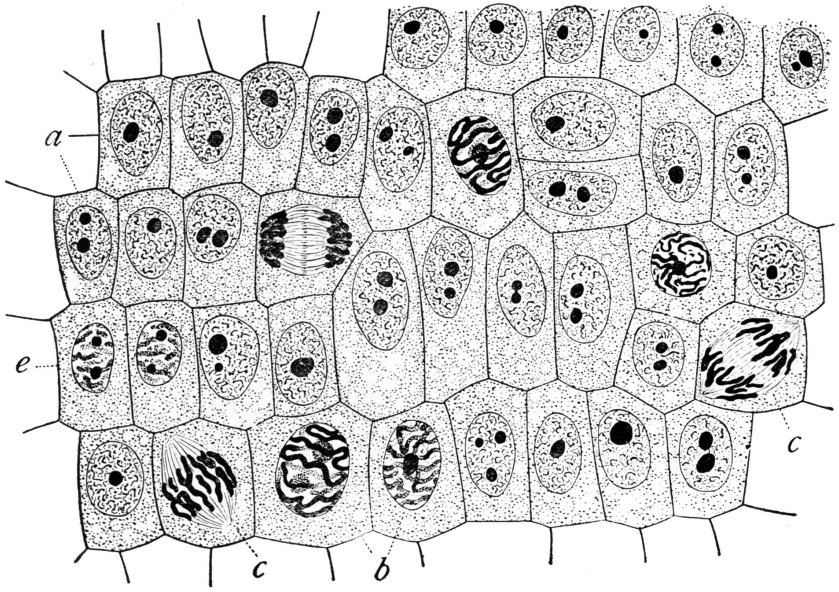

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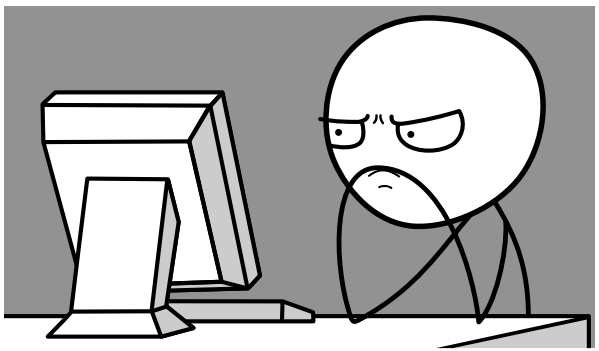
Experiments can be carried in reality or in simulation

Context

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



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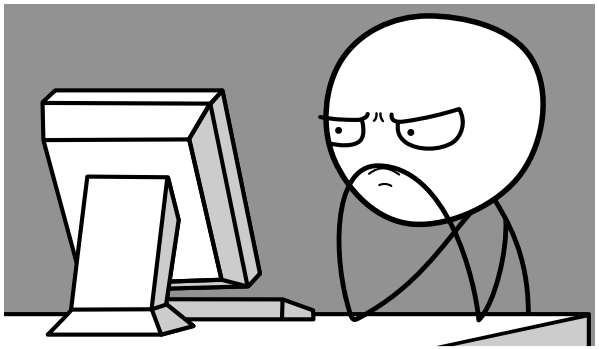

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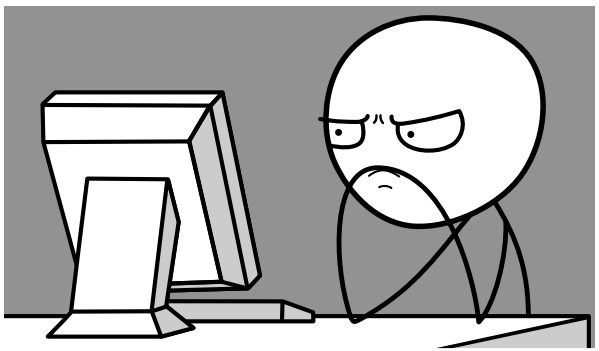

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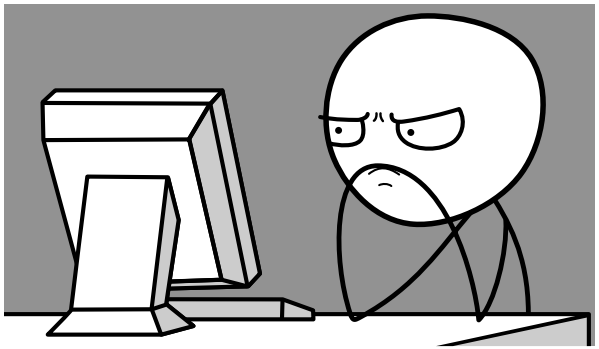

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Holy Grail: Predictive Simulation on a “Laptop”

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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- Experiment methodology, to bias or not to bias
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Full reimplementation of MPI on top of SIMGRID

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Emulation: how?

- Computations run for real on a laptop
- Communications are faked, good fluid network models
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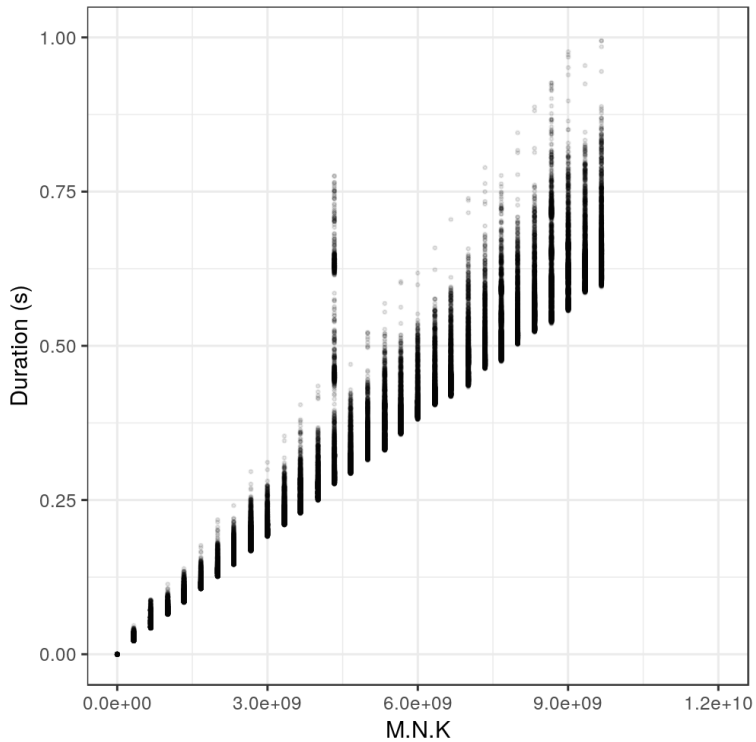
Contribution: Skip the expensive computations (mostly `dgemm`) and replace them by performance models

Modeling Commputations

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



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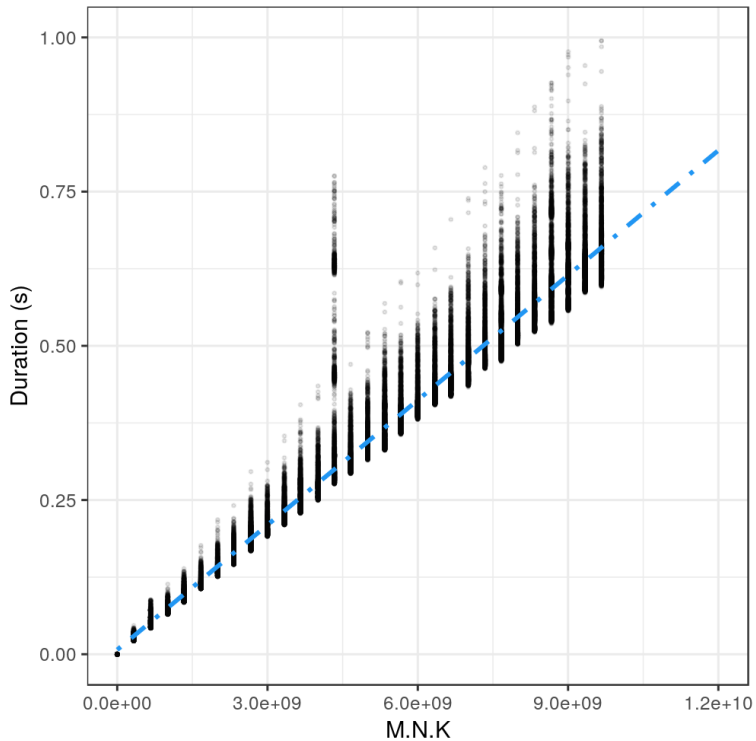

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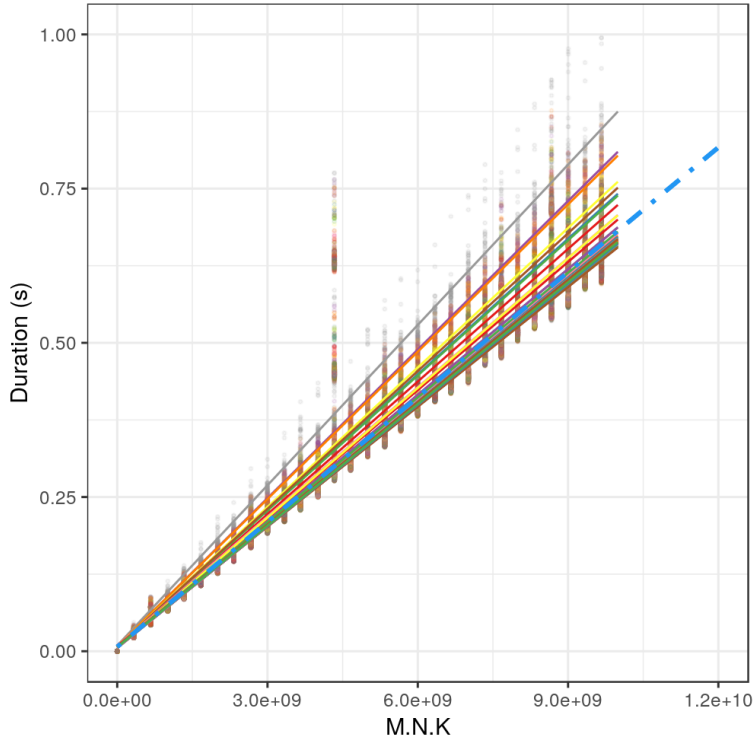
Different color $\Rightarrow$ different host



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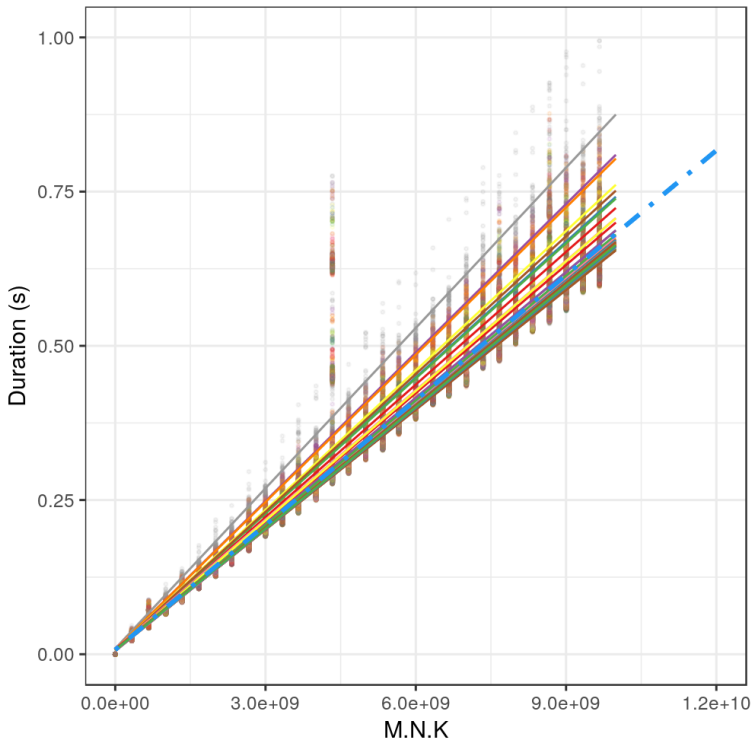
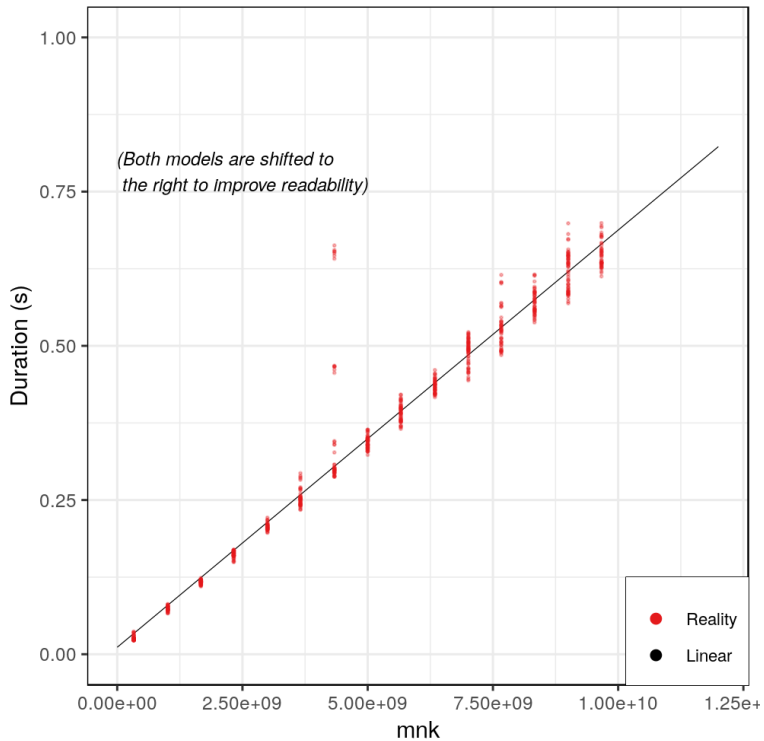


For a particular host



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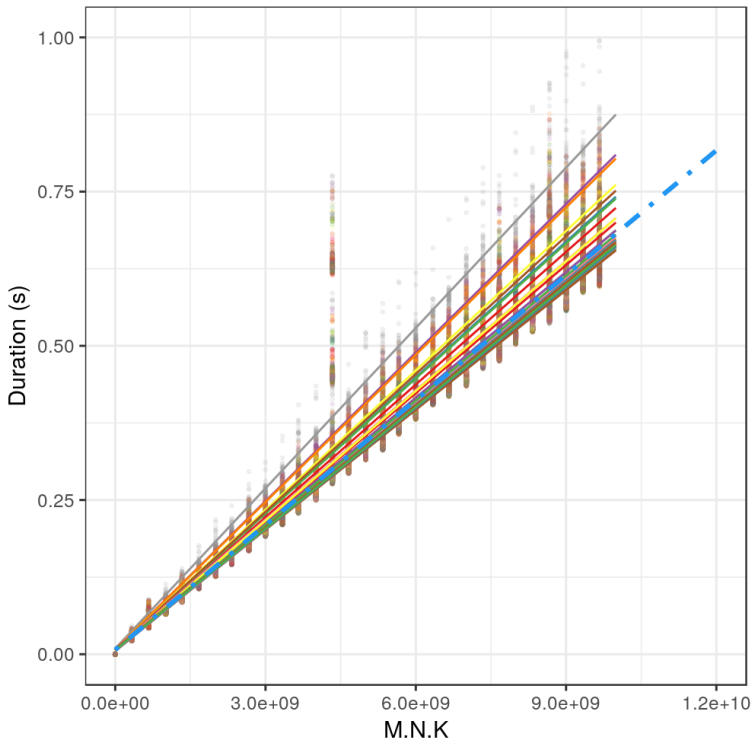

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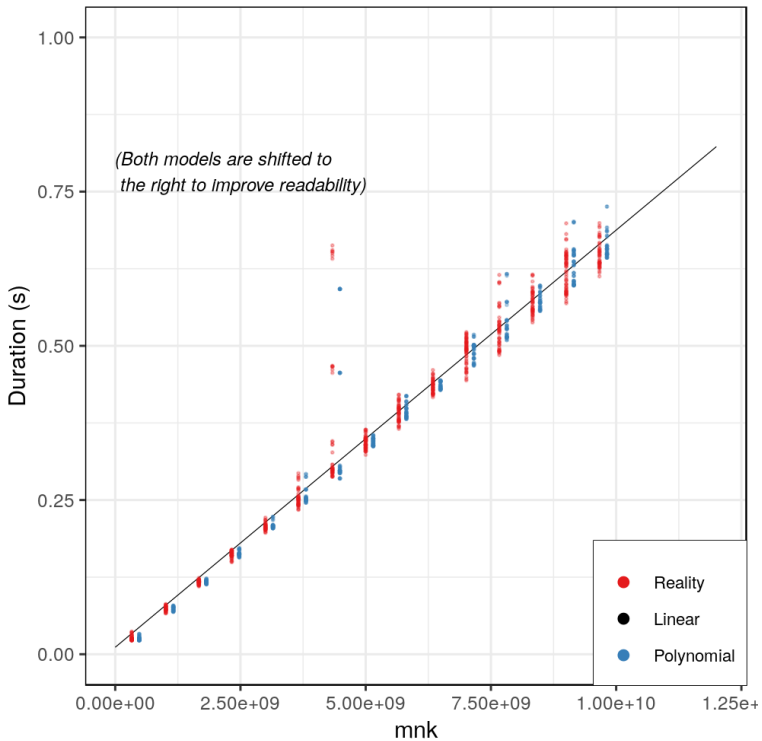

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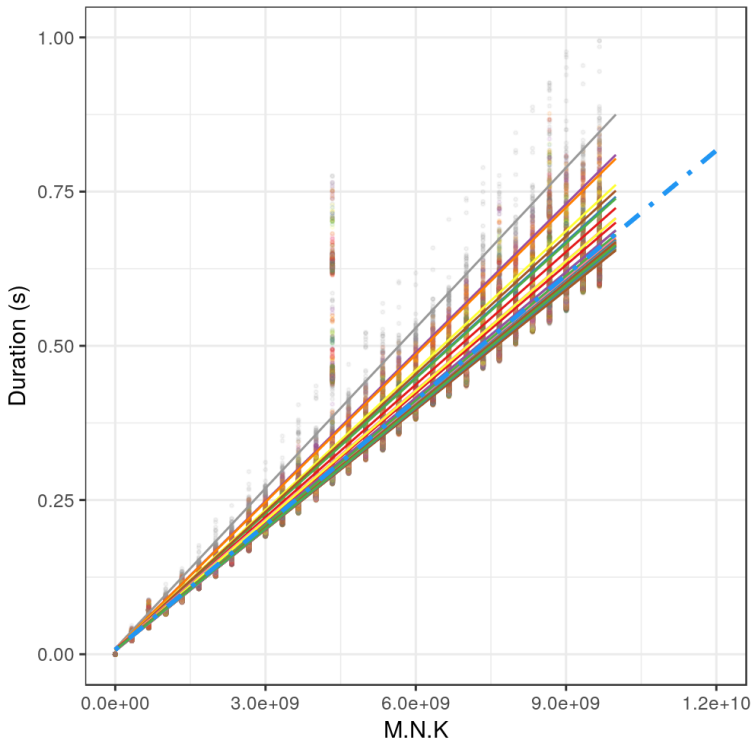

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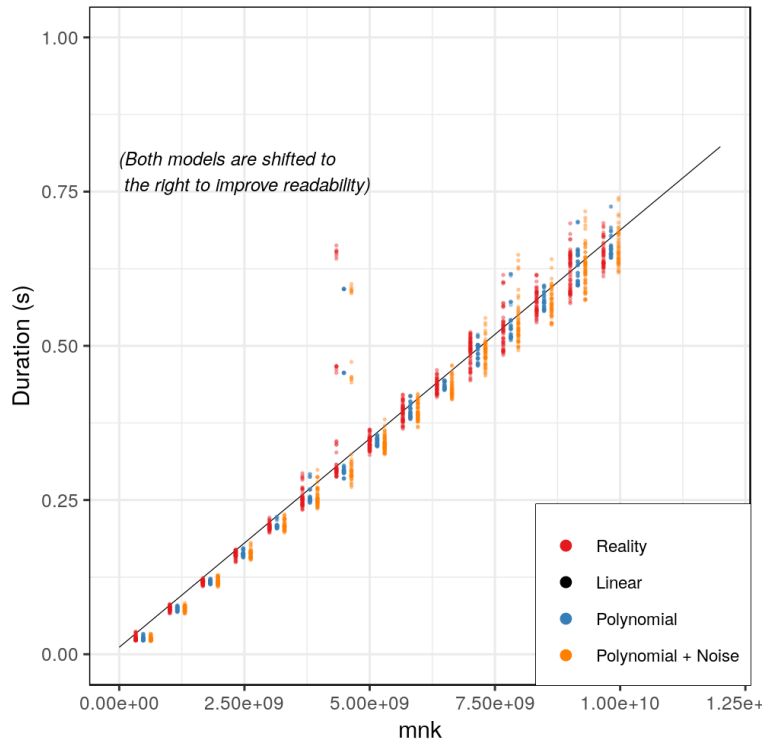

Modeling Communications

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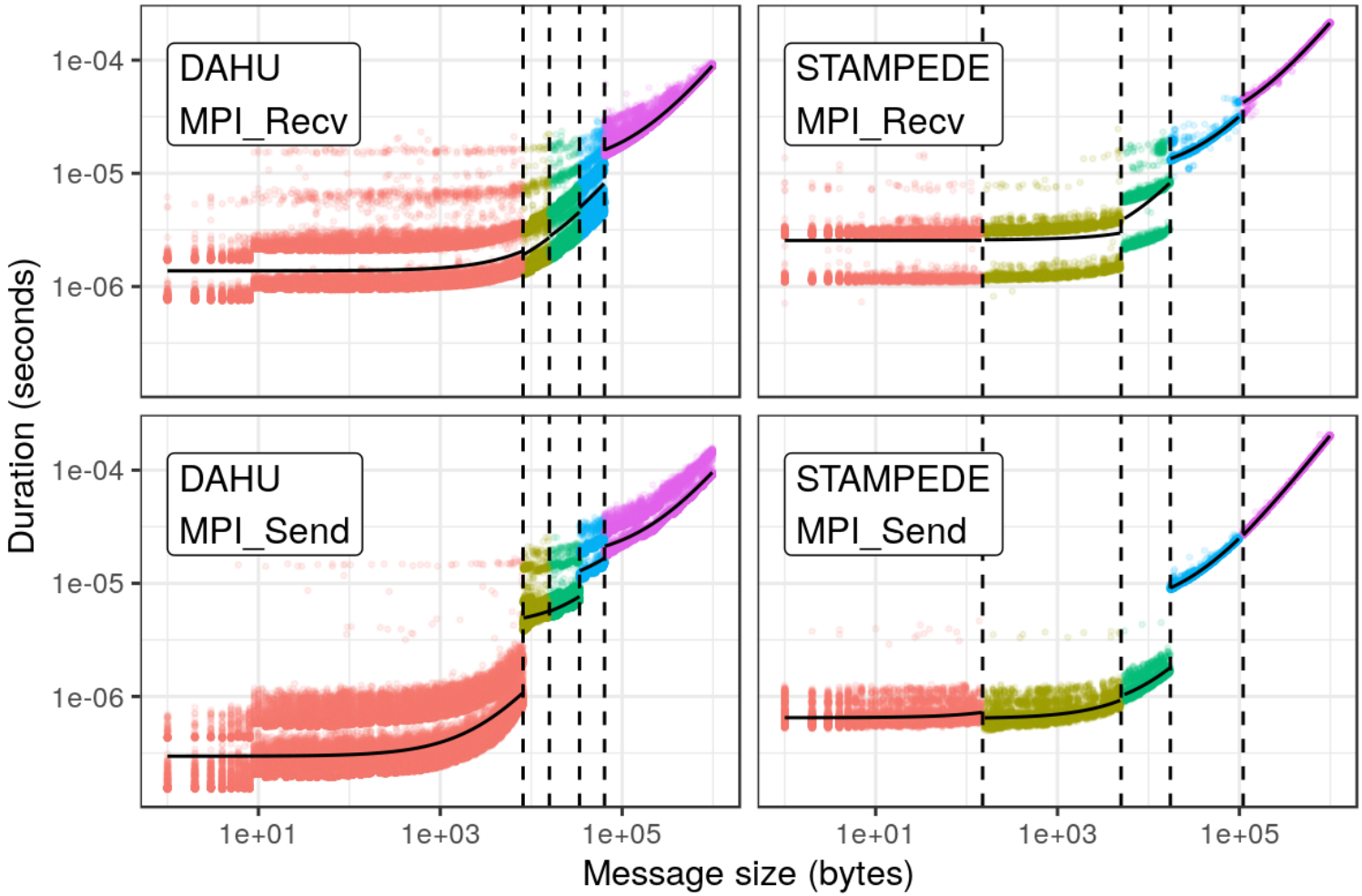

Parenthesis: on the difficulties of experimentation

Experimental biases when measuring `dgemm` or MPI durations

Effect on durations, but also other metrics (e.g. CPU frequency)

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Bias may be desirable in some situations