Large scale parallel simulation for Discrete Element Method

PCOG team meeting

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November 27th, 2017

General overview

- **Background**
  - Bachelor in Scientific Computing (2013)
  - Engineering degree in Applied mathematics → Numerical simulation and Data Science (2016)
  - Master degree in Geoscience and Environment (2016)
- **Experiences**
  - Transport of reagent in a porous medium (EDF/INRIA, 2014)
  - Domain decomposition for ADE from the modeling of electrical transmission network (RTE/CDCSP, 2016)
  - Optimization of a 2D PIC code for satellite thruster (SAFRAN/LPP, 2016)
- Since March 2017
  PhD student in LuxDEM team → **Large scale parallel simulation for Discrete Element Method**

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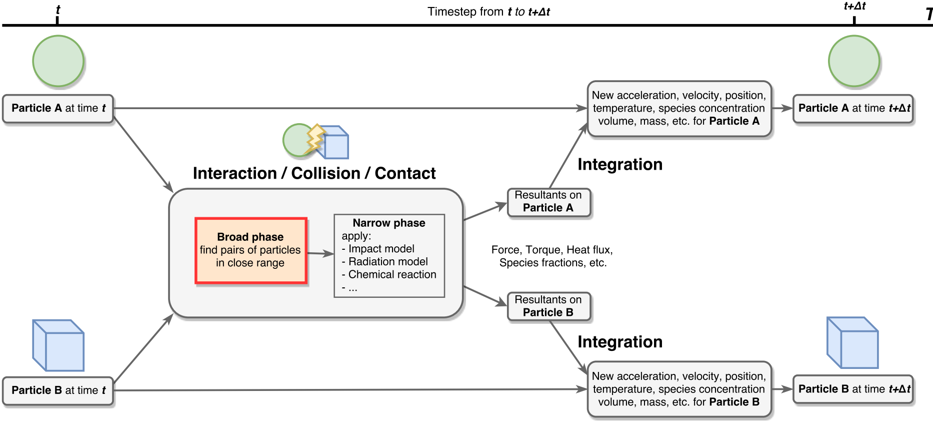
BROADPHASE



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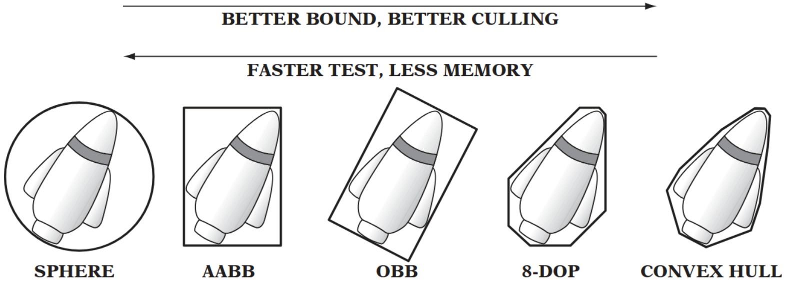
Bounding Volume approach



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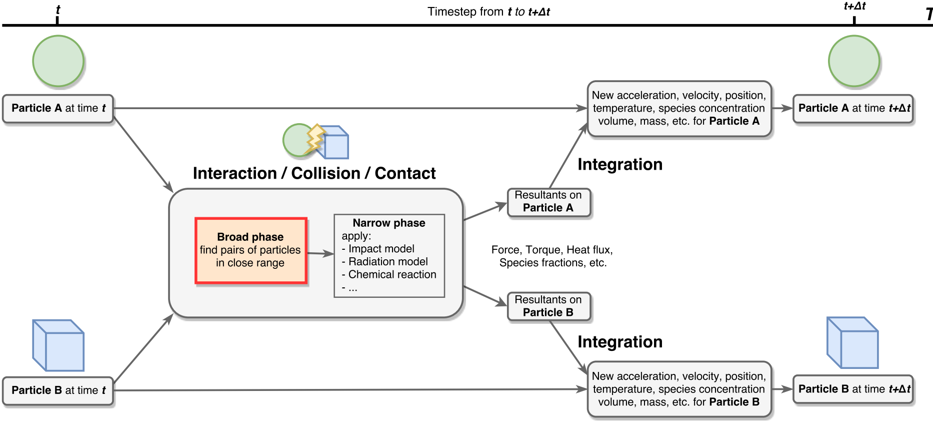

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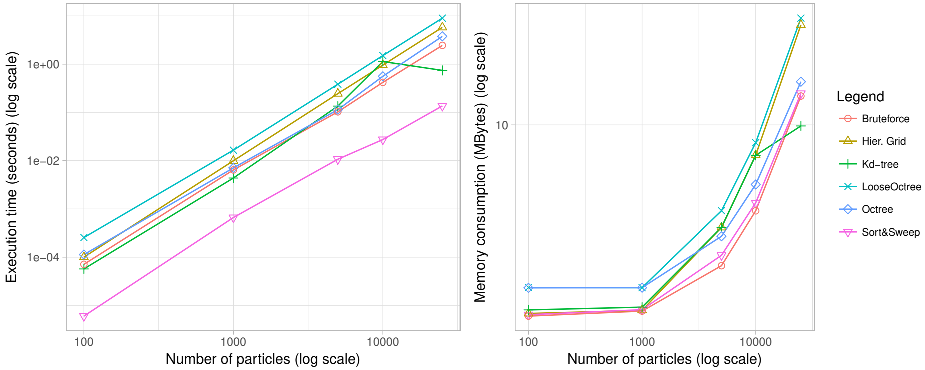
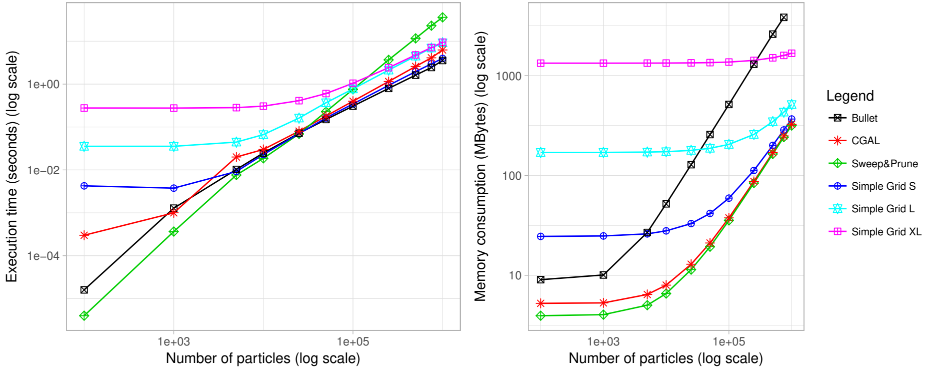
Memory/Execution time for *Slow Algorithms*



Trees algorithms are slow

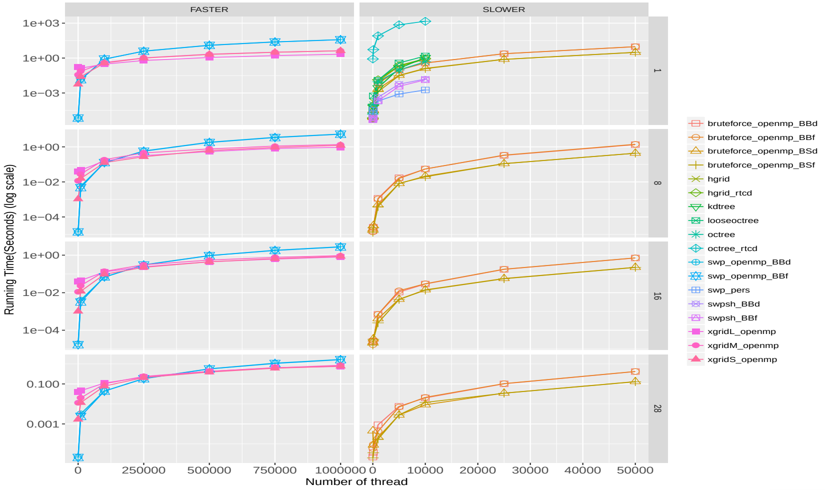
Memory/Execution time for *Fast Algorithms*



Bullet is fast but high memory consumption

Small number of particles (CGAL, SWP) Vs Big number of particles (xgrid)

Parallel Broadphase : Experimental methodology



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Roofline model

Provide graphical aid for **realistic expectations of performance and productivity**

CPU's limit and which optimization can we applied

Two major bottlenecks

- Memory bandwith
- Computationnal speed

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What do we need ?

Peak performance

$$peak = nOps \ x \ freq \ x \ nCores$$

$\Rightarrow$ CPU limit

Operational intensity

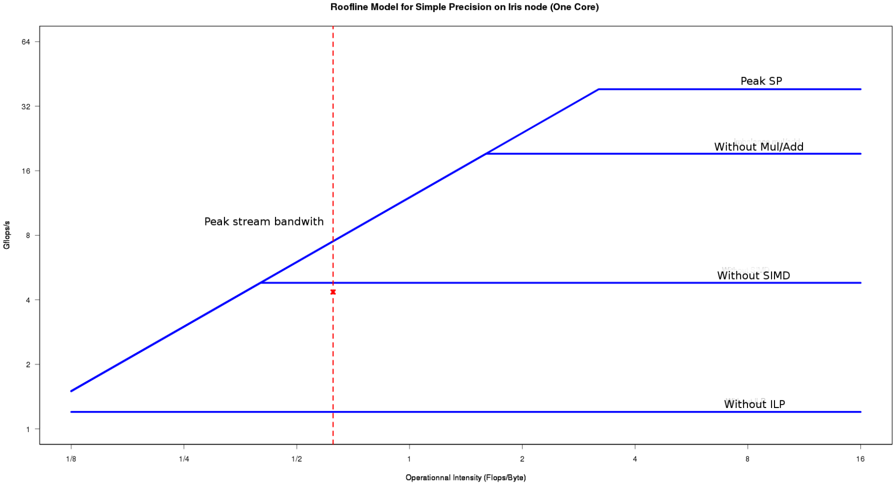
$$OI = \frac{Flops}{MemopsxSizeOfData}$$

$\Rightarrow$ Algorithm limit

Attainable Gflops/s

$$min = \begin{cases} Peak\ floating\ point\ performance, \\ Peak\ memory\ bandwidth \times OI. \end{cases}$$

Roofline plot : BruteForce



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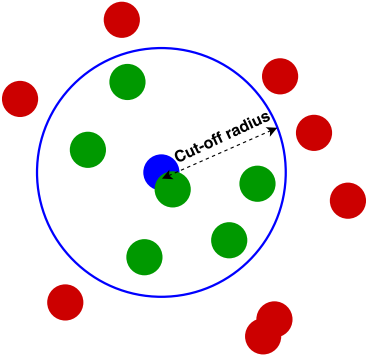
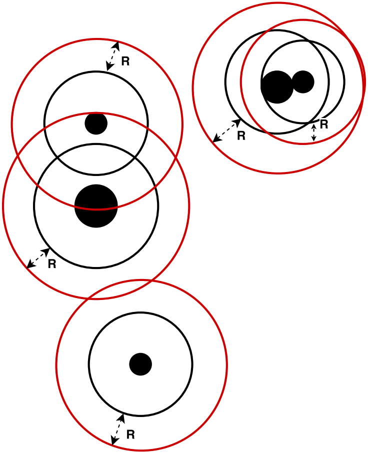
Relaxation broadphase

Broadohase ⇒ likely collision in neighborhood ⇒ 65%
Neighborhood defined by a cut-off radius



Relaxation broadphase



For all particles, if $dx = V * dt < R$ at t_i, no need to update the neighborhood at t_{i+1} $\Rightarrow$ **Skip broadphase**

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Thank you for your attention

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