Material-Point Method Parallel Performance

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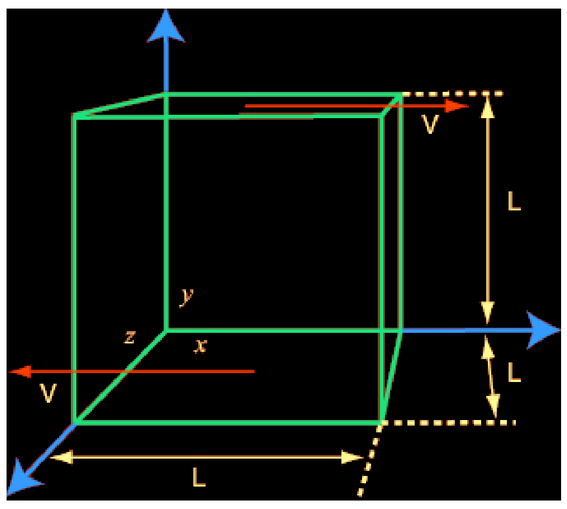
Study weak parallel scalability (i.e. fixed problem size per processor) for two problems (1) a cube (2) a rectangular brick

Problem 1: Shear a cube of material – prescribe equal and opposite velocity on the top and bottom faces



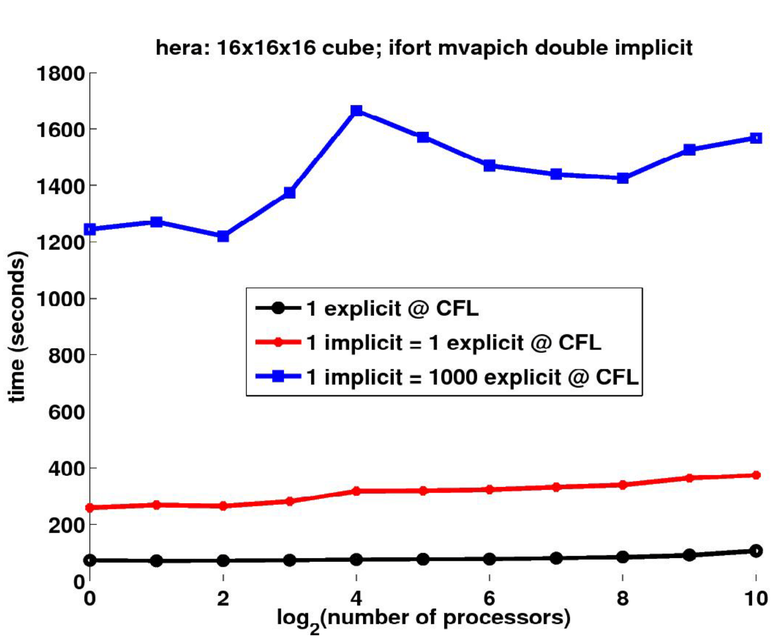
Material:
Elastic Poly Si Cube
1mm x 1mm x 1mm

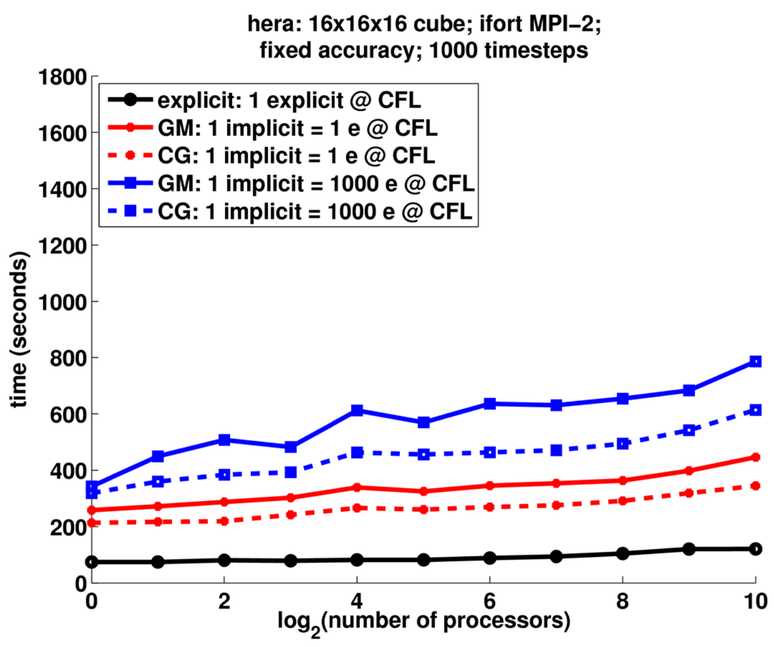
E=169 GPa
ν=0.22
ρ =2330 kg/m^3

Initial Discretization:
16 x 16 x 16 mesh
or
32 x 32 x 32 mesh
8 material pts/cell

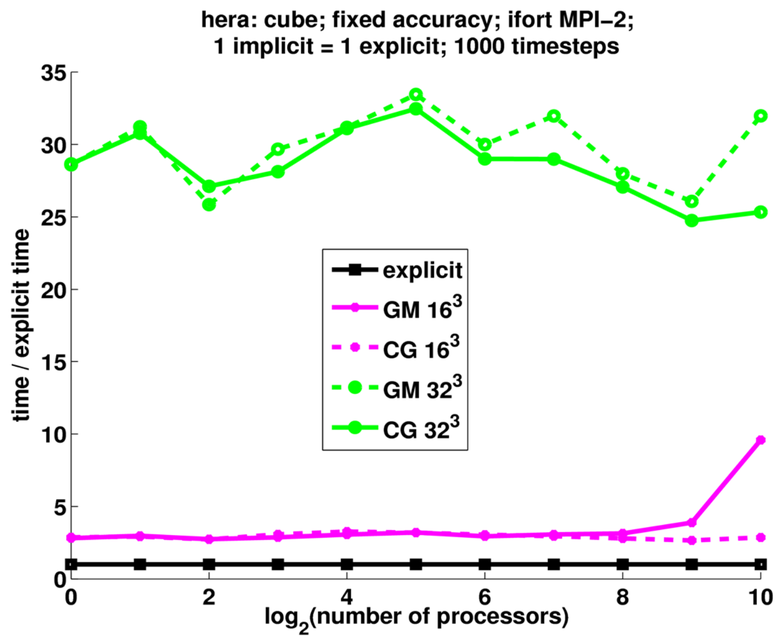
Run 1000 timesteps

2010 results





2011 results



Tested up to 1024 processors on Hera* at LLNL (4M elements, 32M material points)
Good parallel efficiency using conjugate gradient (CG) and GMRES (GM) solvers

Note: an implicit timestep takes 2-3x the explicit for 16x16x16 problem

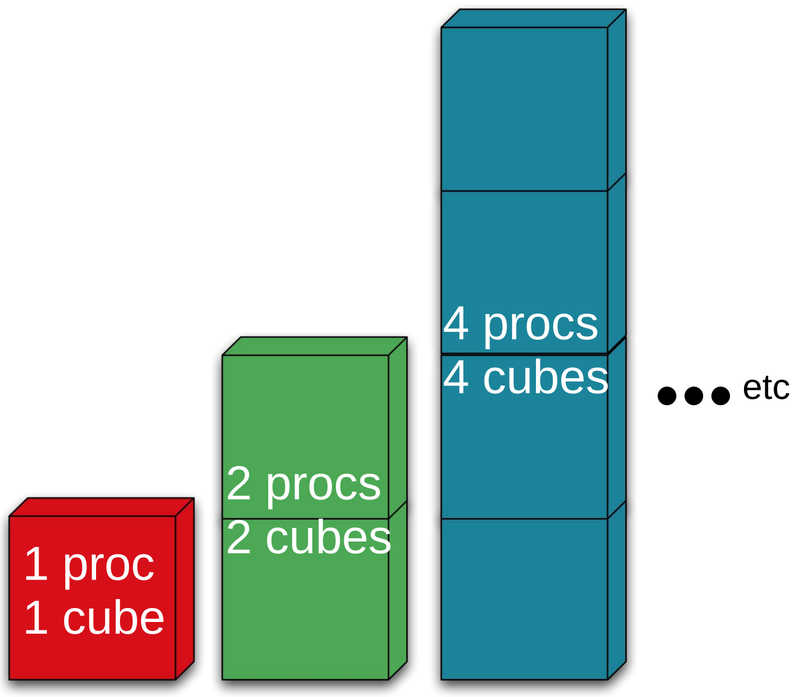
Problem 2: Shear a rectangular brick of material – increase aspect ratio with problem size

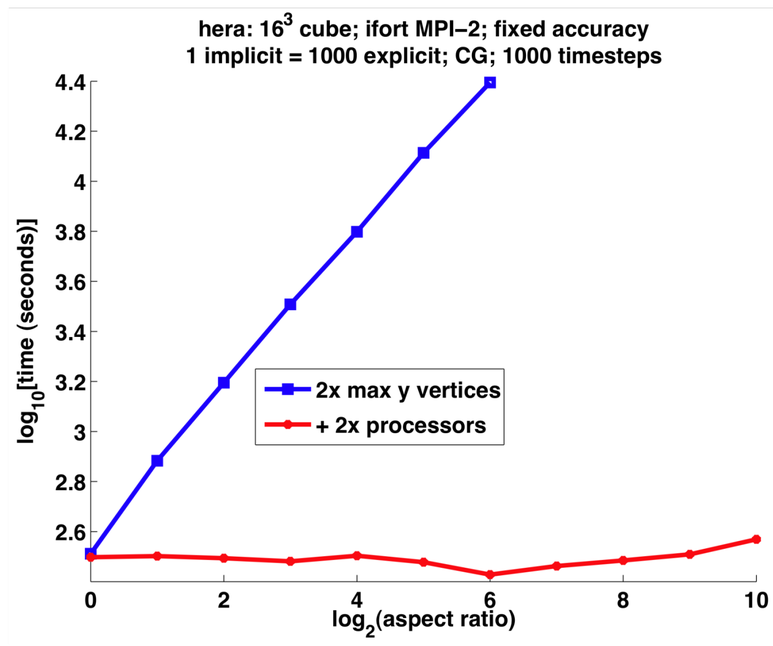
Start with a 16x16x16 cube, then double the problem size by doubling the aspect ratio.

The blue curve shows serial execution time (increasing with increasing problem size).

The red curve shows parallel execution time (constant with increasing problem size).

Aspect ratio does not affect parallel efficiency.





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*Hera has 864 nodes, each with 16 processors, connected by low-latency, high-bandwidth Infiniband.