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Parallel-in-time integration - Status Report

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Progress

- Addressing applicability of Parareal for gravity wave propagation.
- Extending code to hybrid space-time parallelization.
- **Big open question:** "Enhancing" Parareal for explicit integrators for nonlinear problems.
- Addressing applicability of
  "*Parallel Full Approximation Scheme in Space and Time*" *(PFASST)*
  developed by M. Emmett, M. Minion (UNC) for Boussinesq system.
- Write up of recent results in [1].

Explicit Parallel-in-time Integration of a Linear Acoustic-Advection System, ICS-Preprint 2011-05.

More Complex Equations

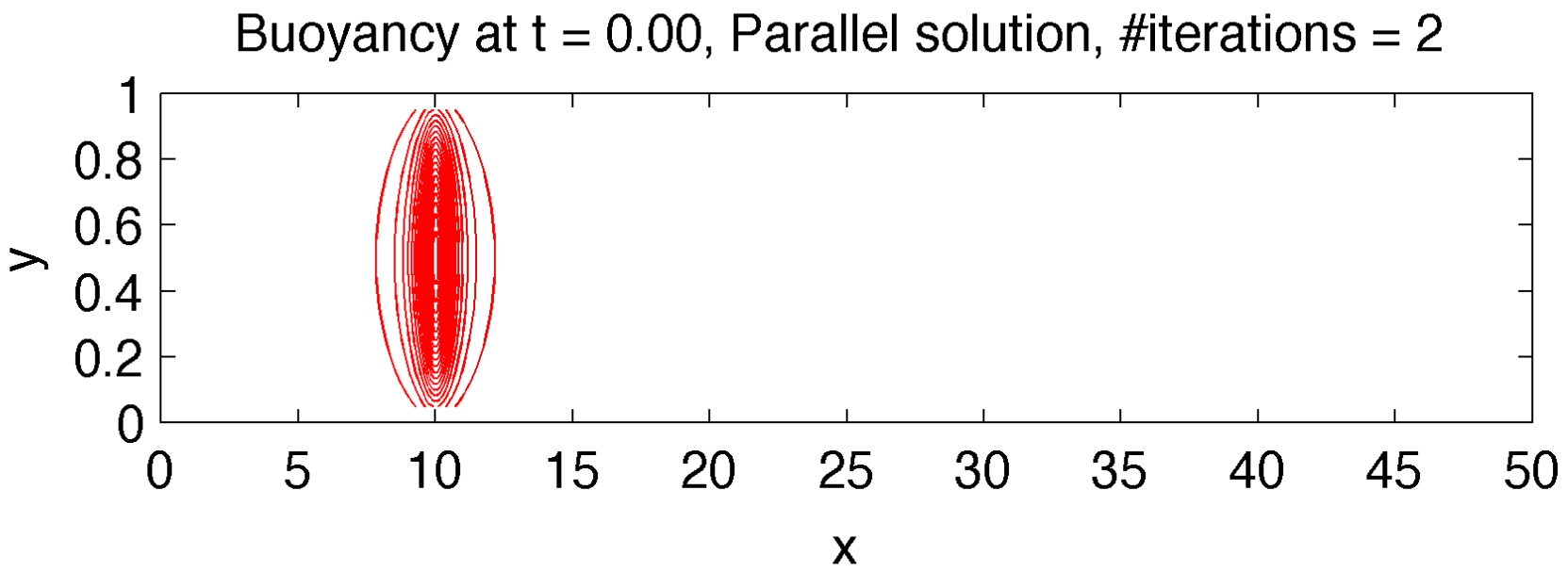
Linear Compressible Boussinesq System

$$
\begin{aligned}
u_t + Uu_x + Wu_z + c_s p_x &= 0 \\
w_t + Uw_x + Ww_z + c_s p_z &= b \\
b_t + Ub_x + Wb_z + N^2 w &= 0 \\
p_t + Up_x + Wp_z + c_s (u_x + w_z) &= 0
\end{aligned}
$$

Test Problem

Gravity wave in a pipe, [Skamarock and Klemp, MWR 1994].

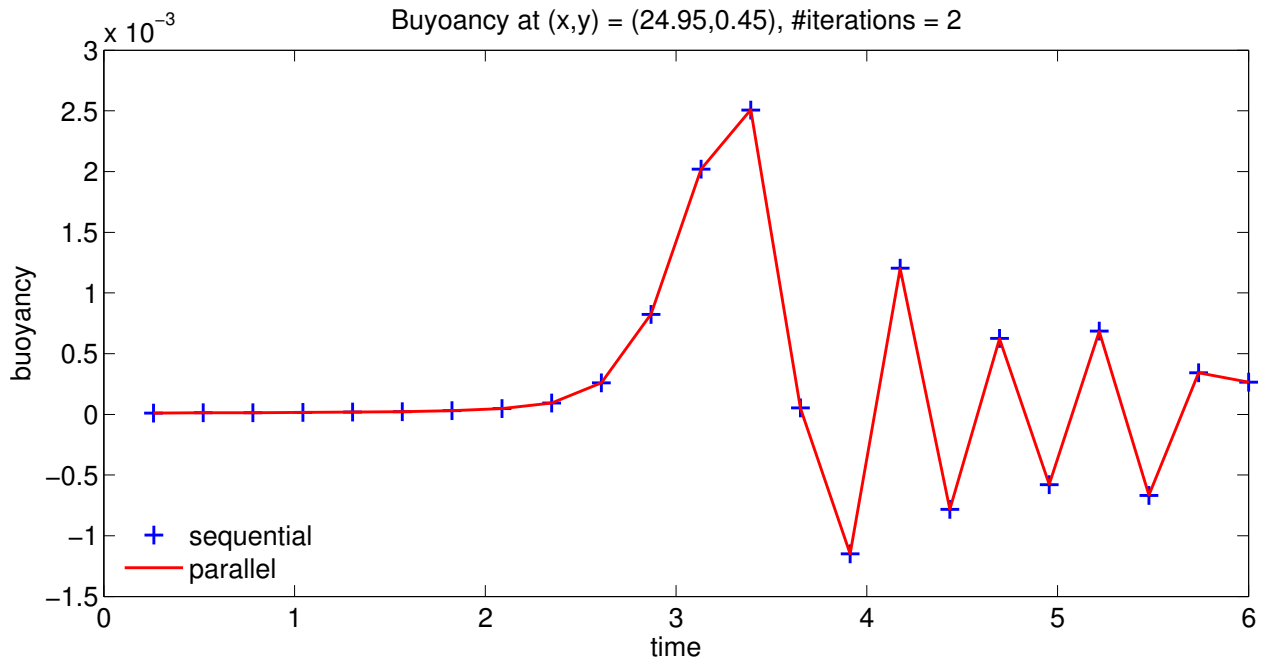
Parallel Solution



Speedup

$$\text{Speedup } s = \frac{\text{Runtime sequential solution}}{\text{Runtime parallel solution}} = 1.5 \text{ on 8 cores.}$$

Buoyancy over Time



Relative Error

$$\text{Relative error } \frac{||\mathbf{b}_{\text{par}} - \mathbf{b}_{\text{seq}}||}{||\mathbf{b}_{\text{seq}}||} \approx 5 \cdot 10^{-2}$$

Next Step: Hybrid Space-Time Parallelization

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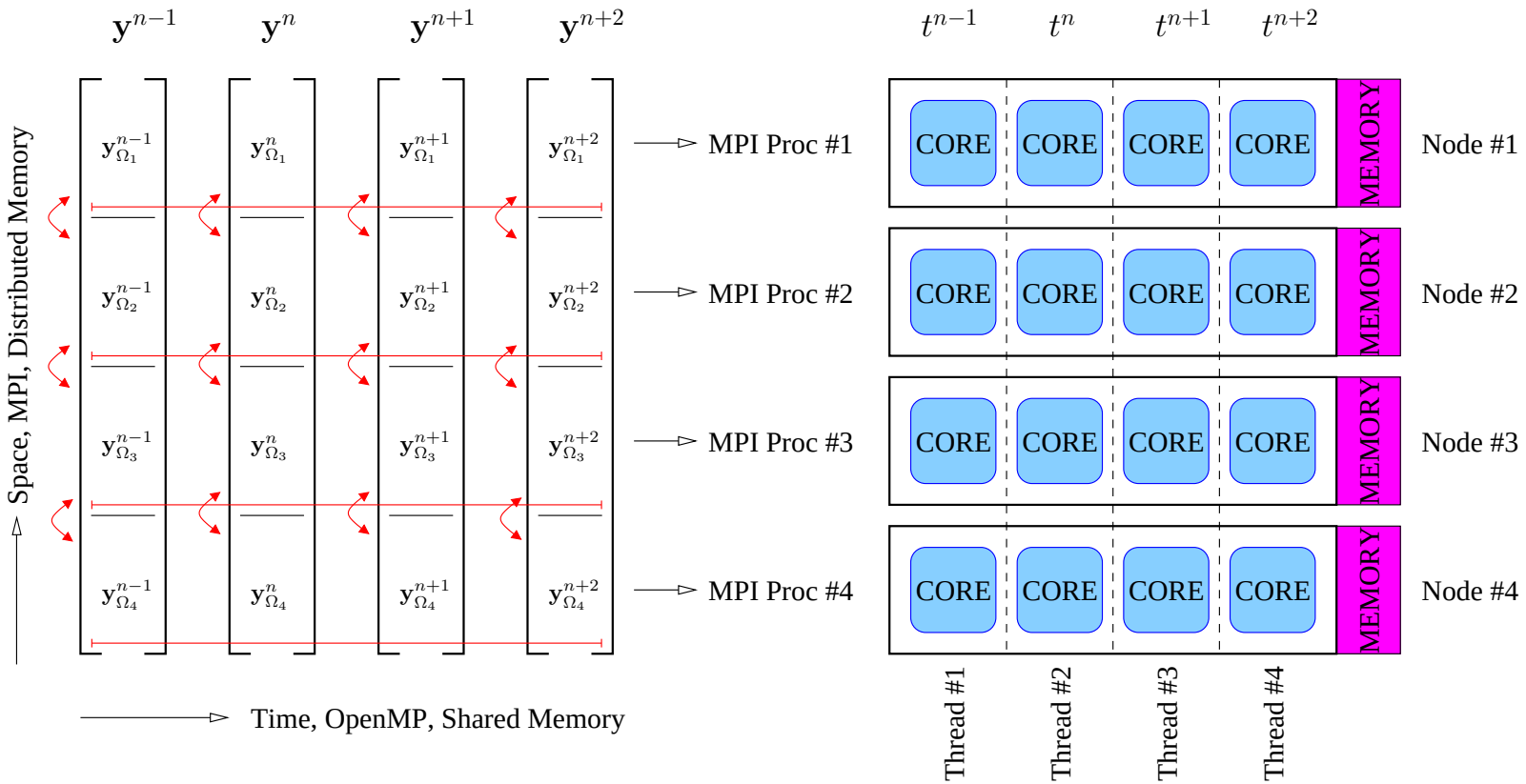

Goal:

Demonstrate that hybrid approach reduces run time after spatial parallelization has saturated.