Performance, Portability and Productivity for 3D Wave Models

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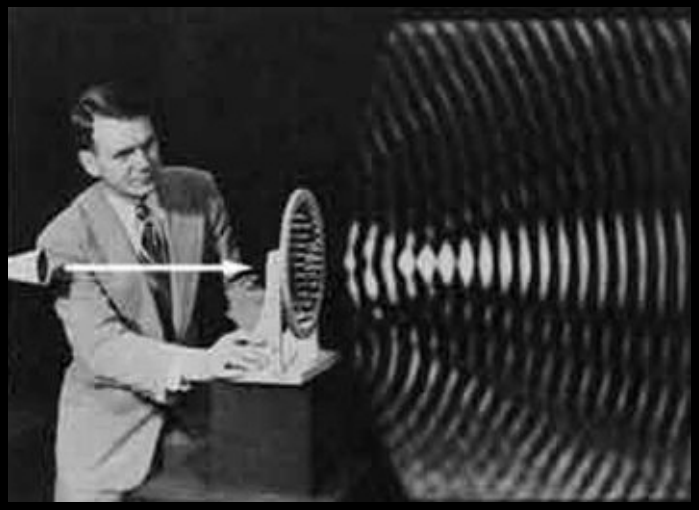
PPar 2015 Intake



Let's break that down:

Performance (*n.*)

For computationally intensive algorithms (like many physical models), obtaining results in a timely manner is critical

Portability (*n.*)

With the plethora of HPC architectures available, programmers should be able to run their codes on newer, more performant platforms without rewriting and retuning

In addition to performance and portability, it is critical to retain **Performance Portability**: high performance across different architectures

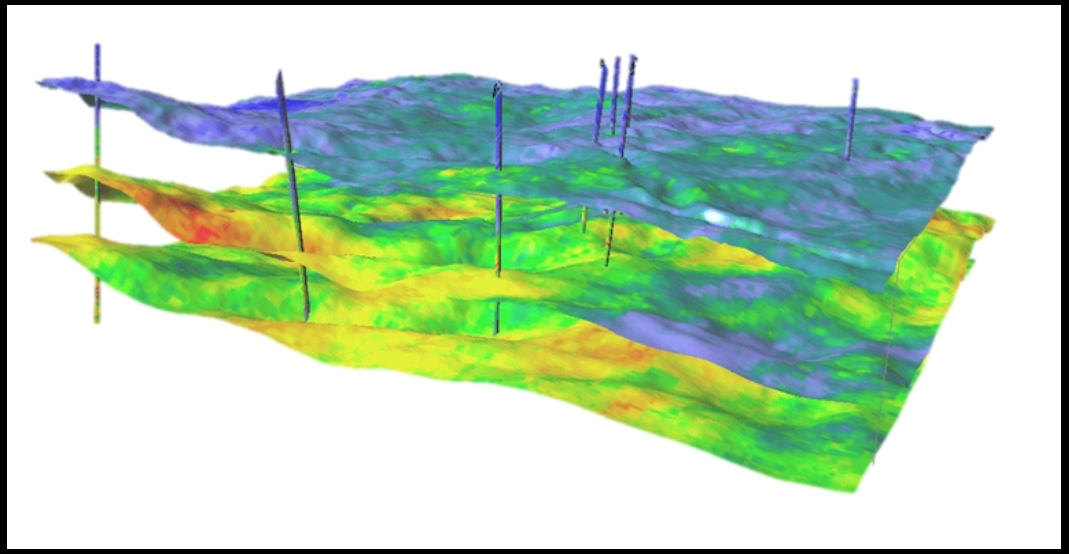
Productivity (*n.*)

Computational scientists shouldn't need to know how to perform low-level optimisations to write HPC codes

3D Wave Models

Use discretised wave equations (modelled as *stencils*) to simulate wave phenomena

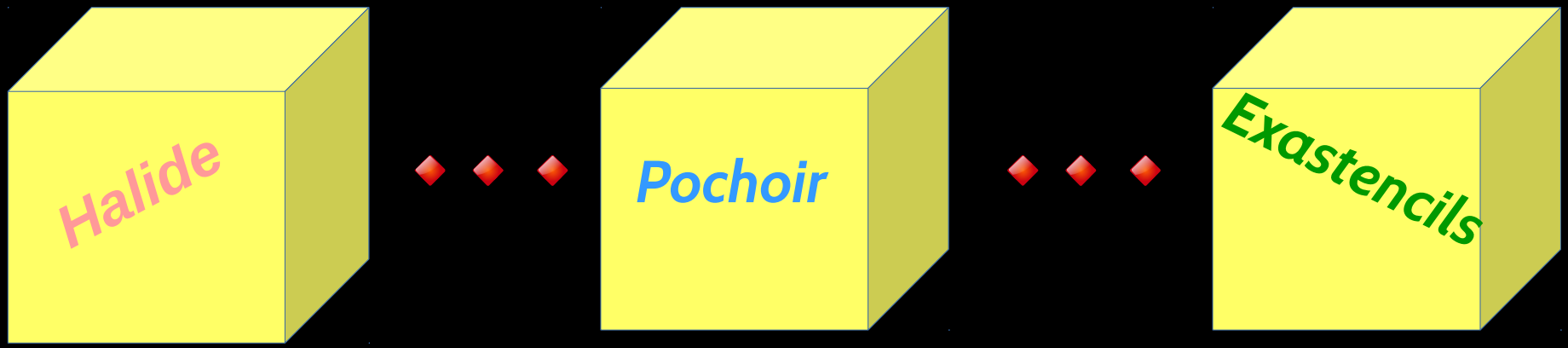
Can be difficult to model absorbing boundary conditions, which are not currently expressible in higher-level abstractions



Seismic data

Room Acoustics

There are many frameworks currently available that focus on stencils



However, none of these provide a solution which provides all three of performance, portability and productivity for 3D wave models

Instead: Use a Modular Approach

Computational scientists write their codes in an existing, easily programmable DSL

DSL writers implement their abstractions with a hardware-agnostic intermediary language

A compiler handles the low-level details of specialising for a particular hardware

The good news is that this goal is not far from realisation!

Lift aims to serve as an intermediary language between portable and productive DSLs and high performance code

Proposed Workflow

computational scientist

productive, portable high-level abstractions

DSL

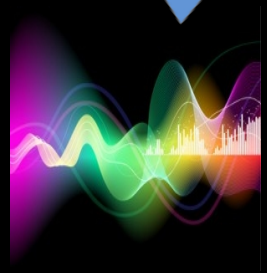
LIFT

intermediary language

search optimisation space for best model version

rewrite rules

$$map\ f \rightarrow join \circ map\ (map\ f) \circ split\ n$$
$$map\ f \circ map\ g \rightarrow map\ (f \circ g)$$
$$reduce\ f\ z \rightarrow reduce\ f\ z \circ reducePart\ f\ z$$



performant, portable, productive
3D wave model code

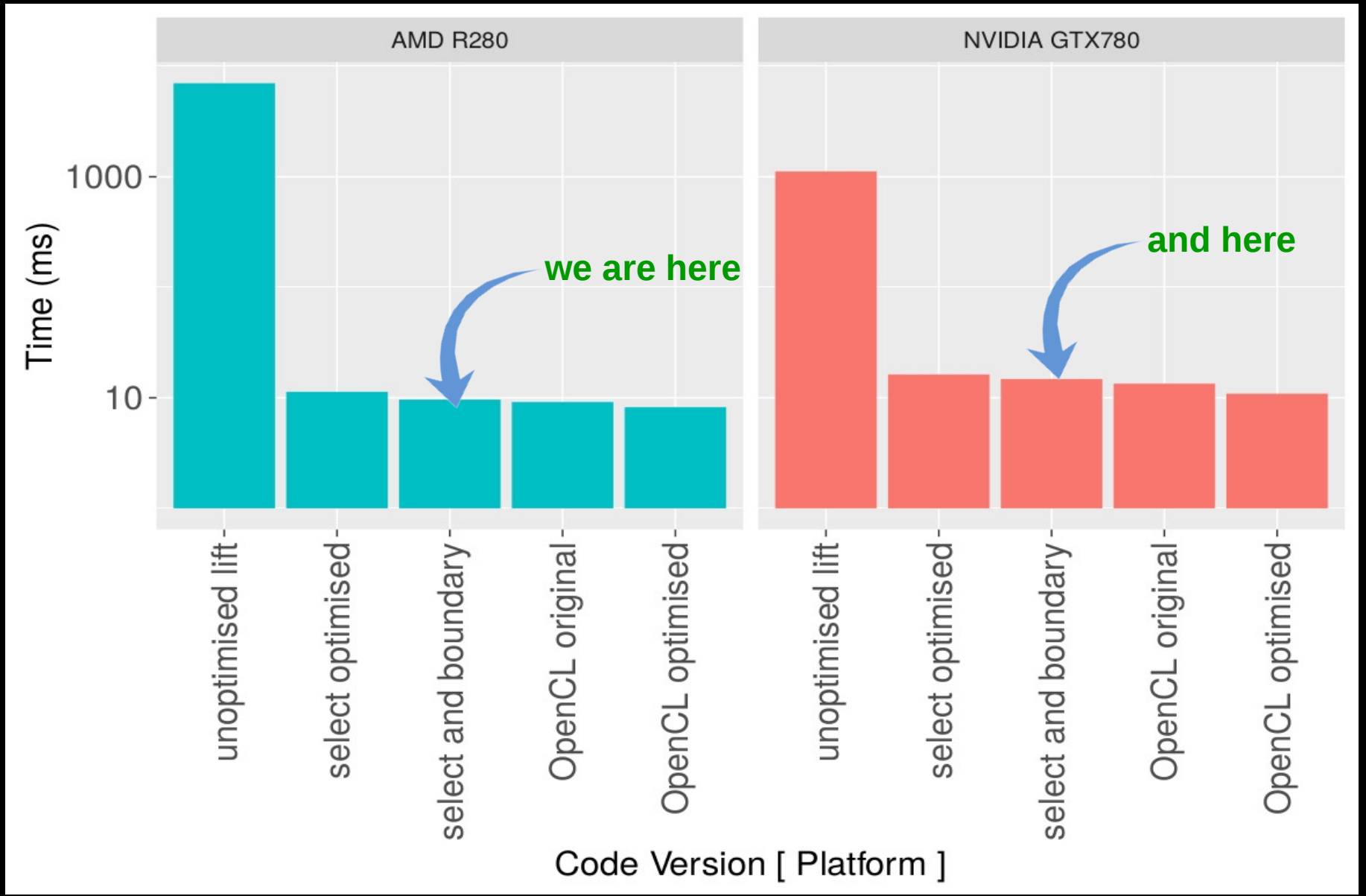
Current Work

Adapt *Lift* to abstract absorbing boundary conditions for 3D wave models like room acoustics and ground penetrating radar simulations

Implement optimisations for 3D stencils in *Lift*

Extend existing stencil DSL to compile 3D wave models into *Lift*

Preliminary Results



Conclusions

- There are currently no frameworks that provide performance, portability and productivity for 3D wave-based models
- By using the *Lift* framework as an intermediary stage, current stencil based DSLs could be adopted to create performant, portable and productive 3D wave simulations