# Parallel Finite Element assembly

Michael Wathen*

April 28, 2016

**Abstract**

## 1 Introduction

Many industrial and geophysical scientific computing problems require discrete solving techniques for partial differential equations (PDEs). The two main components of a PDE solving are:

- Discretisation;
- Linear/non-linear solve.

## 2 Assembly

## 3 Results

### 3.1 Laplacian

Consider Laplace's equation with non-homogeneous Dirichlet boundary conditions

$$\begin{aligned} \Delta u &= f \text{ in } \Omega, \\ u &= g \text{ on } \partial\Omega. \end{aligned}$$

### 3.2 MHD

## 4 Conclusion

*Department of Computer Science, The University of British Columbia, Vancouver, BC, V6T 1Z4, Canada, mwathen@cs.ubc.ca.

| MPI processes | DoFs | | | | | | |
|---|---|---|---|---|---|---|---|
| | 375 | 2,187 | 14,739 | 107,811 | 823,875 | 6,440,067 | 50,923,779 |
| 1 | 1.88e-01 | 4.99e-02 | 6.44e-01 | 2.69e+00 | 1.86e+01 | 1.49e+02 | - |
| 2 | 5.59e-02 | 7.60e-02 | 1.91e-01 | 1.38e+00 | 1.04e+01 | 7.92e+01 | - |
| 4 | 3.12e-02 | 3.78e-02 | 1.29e-01 | 1.05e+00 | 5.66e+00 | 4.19e+01 | - |
| 8 | 2.61e-02 | 3.45e-02 | 8.71e-02 | 5.31e-01 | 3.11e+00 | 2.32e+01 | 1.88e+02 |
| 16 | 7.83e-02 | 8.45e-02 | 1.16e-01 | 4.34e-01 | 2.12e+00 | 1.34e+01 | 9.94e+01 |
| 32 | 1.45e-01 | 1.33e-01 | 2.48e-01 | 3.17e-01 | 1.69e+00 | 1.20e+01 | 9.14e+01 |

Table 1: Assemble time

| MPI processes | DoFs | | | | | | |
|---|---|---|---|---|---|---|---|
| | 375 | 2,187 | 14,739 | 107,811 | 823,875 | 6,440,067 | 50,923,779 |
| 1 | 1.15e-01 | 3.29e-02 | 3.67e-01 | 4.50e+00 | 4.34e+01 | 3.93e+02 | - |
| 2 | 1.31e-02 | 2.19e-02 | 2.12e-01 | 2.90e+00 | 2.79e+01 | 1.92e+02 | - |
| 4 | 4.32e-03 | 1.42e-02 | 1.74e-01 | 1.46e+00 | 1.40e+01 | 1.21e+02 | - |
| 8 | 4.47e-03 | 1.18e-02 | 8.42e-02 | 1.18e+00 | 1.18e+01 | 9.24e+01 | 7.76e+02 |
| 16 | 1.35e-02 | 2.38e-02 | 8.28e-02 | 1.26e+00 | 9.11e+00 | 8.00e+01 | 6.71e+02 |
| 32 | 1.58e-02 | 2.28e-02 | 6.27e-02 | 9.35e-01 | 8.70e+00 | 7.66e+01 | 6.50e+02 |

Table 2: Assemble time