Full Title of the Talk

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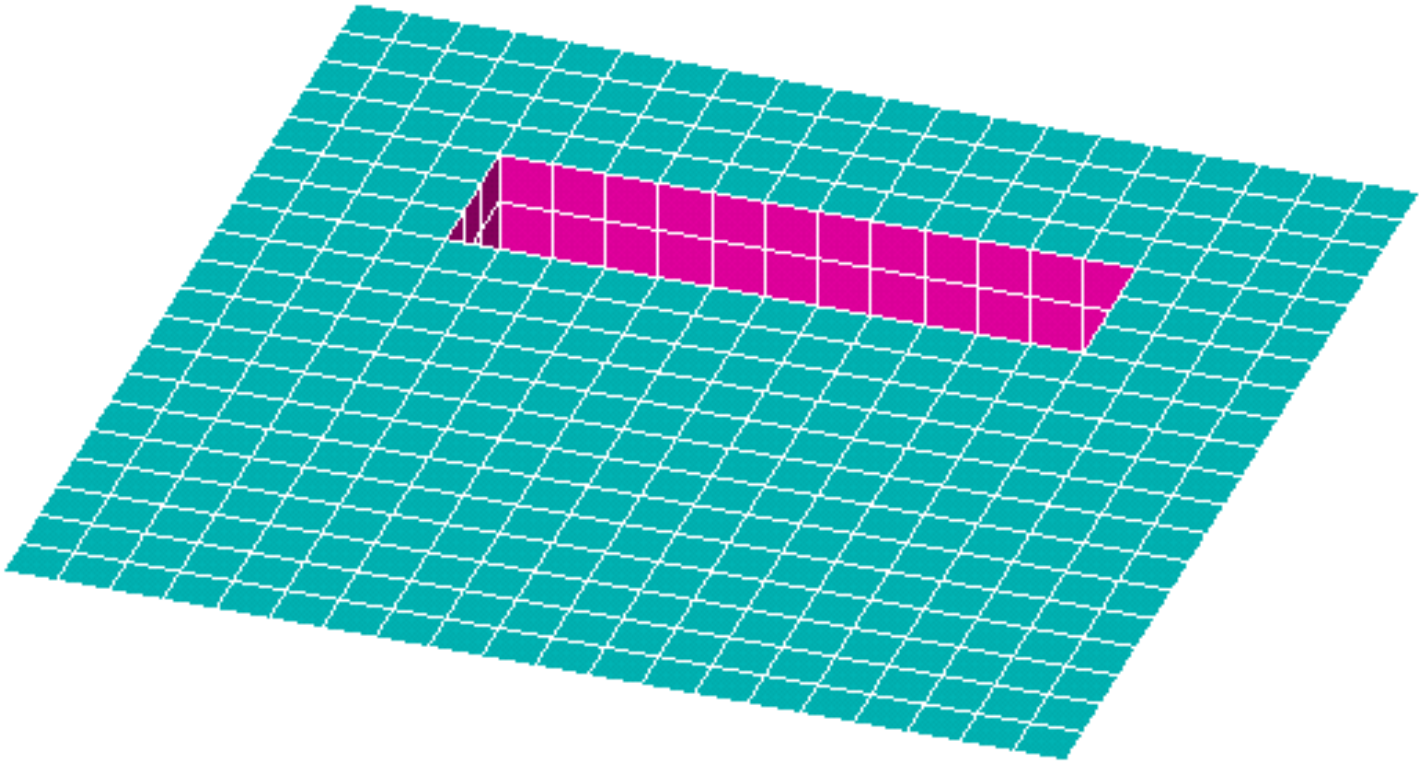
Introdução

- The Boundary Elements Method (BEM)
- Aplicação: Simulação de propagação de ondas no solo.



O Problema

- Implementação fornecida era sequêncial.
- Para 4000 elementos de malha, o tempo total era de 167s.
- Objetivo: Encontrar as rotinas mais custosas e otimizá-las.

O Problema

- Subrotina mais custosa: `Ghmatecd`.
- Constrói as matrizes H & G do problema dinâmico
- Cada fatia 3×3 das matrizes podem ser computadas em paralelo.

Algorithm 1 Creates $H, G \in \mathbb{C}^{(3m)\times(3n)}$

```
1:  procedure Ghmatecd
2:      for j := 1, n do
3:          for i := 1, m do
4:              ii := 3(i − 1) + 1
5:              jj := 3(j − 1) + 1
6:              if i == j then
7:                  Gelement, Helement ← Sing_de(i)
8:              else
9:                  Gelement, Helement ← Nonsingd(i, j)
10:             G[ii : ii + 2][jj : jj + 2] ← Gelement
11:             H[ii : ii + 2][jj : jj + 2] ← Helement
```

Como paralelizar com OpenMP?

Algorithm 2 Creates $H, G \in \mathbb{C}^{(3m)\times(3n)}$

```
1:  procedure Ghmatecd
2:      #pragma omp parallel for collapse(2)
3:      for j := 1, n do
4:          for i := 1, m do
5:              ii := 3(i − 1) + 1
6:              jj := 3(j − 1) + 1
7:              if i == j then
8:                  Gelement, Helement ← Sing_de(i)
9:              else
10:                 Gelement, Helement ← Nonsingd(i, j)
11:             G[ii : ii + 2][jj : jj + 2] ← Gelement
12:             H[ii : ii + 2][jj : jj + 2] ← Helement
```

E na GPU?

O Problema

- `Nonsingd` e `Sing_de` computam uma integral numericamente.

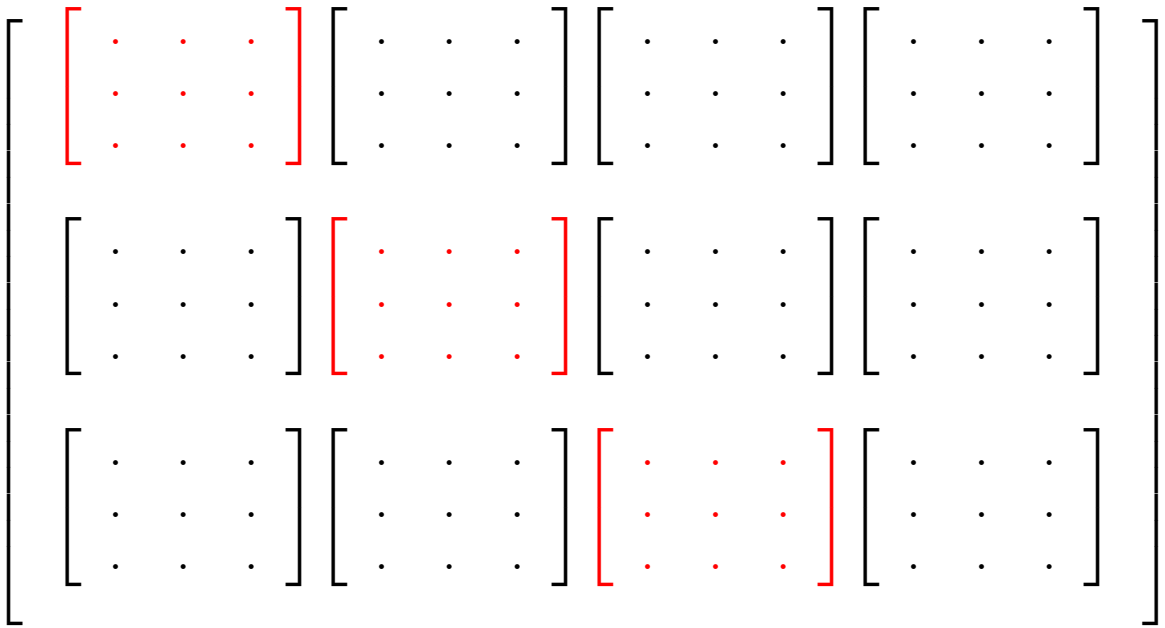
$$\int_a^b f(x)\mathrm{d}x \approx \sum_{i=1}^{g} w_i f(x_i)$$

- Em nosso caso, avaliar $f(x)$ em um ponto x_i é custoso
- Uma forma de paralelizar estas rotinas e fazer uma redução.

Expandindo a rotina `Nonsingd`, temos:

```
1:  procedure Ghmatecd_nonsingd
2:      for j := 1, n do
3:          for i := 1, m do
4:              ii := 3(i − 1) + 1; jj := 3(j − 1) + 1
5:              Allocate Hbuffer & Gbuffer, buffer of matrices 3 × 3 of size g^2
6:              if i ≠ j then
7:                  for y := 1, g do
8:                      for x := 1, g do
9:                          Hbuffer(x, y) ← GenerateMatrixH(i, j, x, y)
10:                         Gbuffer(x, y) ← GenerateMatrixG(i, j, x, y)
11:             Gelement ← SumAllMatricesInBuffer(Gbuffer)
12:             Helement ← SumAllMatricesInBuffer(Hbuffer)
13:             G[ii : ii + 2][jj : jj + 2] ← Gelement
14:             H[ii : ii + 2][jj : jj + 2] ← Helement
15: procedure Ghmatecd_Sing_de
16:     for i := 1, m do
17:         ii := 3(i − 1) + 1
18:         Gelement, Helement ← Sing_de(i)
19:         G[ii : ii + 2][ii : ii + 2] ← Gelement
20:         H[ii : ii + 2][ii : ii + 2] ← Helement
21: procedure Ghmatecd
22:     Ghmatecd_Nonsingd()
23:     Ghmatecd_Sing_de()
```

O Problema



Blocks of Highlighted Text

Block 1

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Block 2

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Multiple Columns

Heading

1. Statement
2. Explanation
3. Example

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Table

Treatments	Response 1	Response 2
Treatment 1	0.0003262	0.562
Treatment 2	0.0015681	0.910
Treatment 3	0.0009271	0.296

Tabela: Table caption

Theorem

Theorem (Mass–energy equivalence)

$E = mc^2$

Verbatim

Example (Theorem Slide Code)

```
\begin{frame}
\frametitle{Theorem}
\begin{theorem}[Mass--energy equivalence]
$E = mc^2$
\end{theorem}
\end{frame}
```

Figure

Uncomment the code on this slide to include your own image from the same directory as the template .TeX file.

Citation

An example of the `\cite` command to cite within the presentation:

This statement requires citation [Smith, 2012].

References

John Smith (2012)

Title of the publication

Journal Name 12(3), 45 – 678.

The End