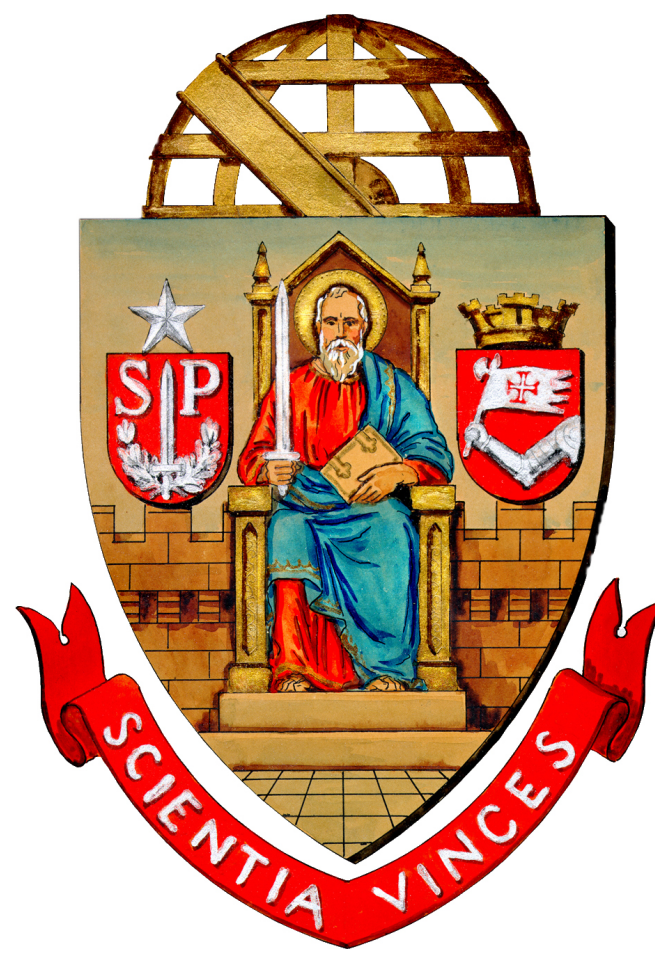# Optimizing a Boundary Elements Method for Stationary Elastodynamic Problems Implementation with GPUs

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Introduction

- The Boundary Element Method (BEM) is a very efficient alternative for modeling unlimited domains
- This method can be used for numerically modeling the stationary behavior of 3D wave propagation in the soil [1]
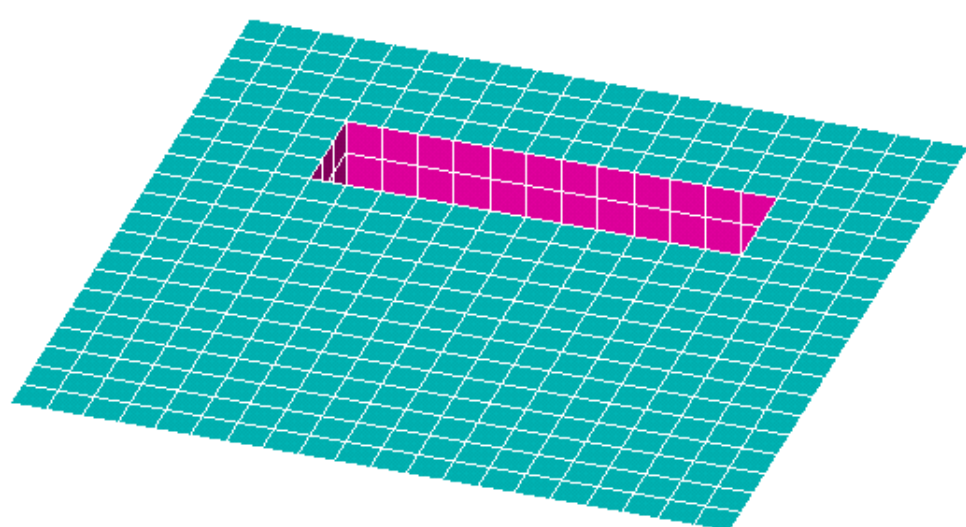- It can be used for analyzing the vibration created by heavy machines, railway lines, or earthquakes

Figure 1: Example of a surface.

BEM Formulation Background

- Boundary Integral Equation for Stationary Elastodynamic Problems [2]:

$$c_{ij}u_j(\xi,\omega) + \int_S t_{ij}^*(\xi,x,\omega)u_j(x,\omega)\mathrm{d}S(x) =$$
$$= \int_S u_{ij}^*(\xi,x,\omega)t_j(x,\omega)\mathrm{d}S(x)$$

- After performing the geometry discretization, the equation above can be represented in matrix form as $Hu = Gt$
- Numerically, these integrals can be computed using the Gaussian quadrature

Objectives

- Bring a legacy implementation of BEM for Stationary Elastodynamics Problems to a contemporary computing scenario, enabling the usage of multicore processors and GPUs
- Accelerate the overall performance to simulate surfaces with a higher number of mesh elements

Results

We applied the parallelization approach described in [3] together with MAGMA's LU decomposition
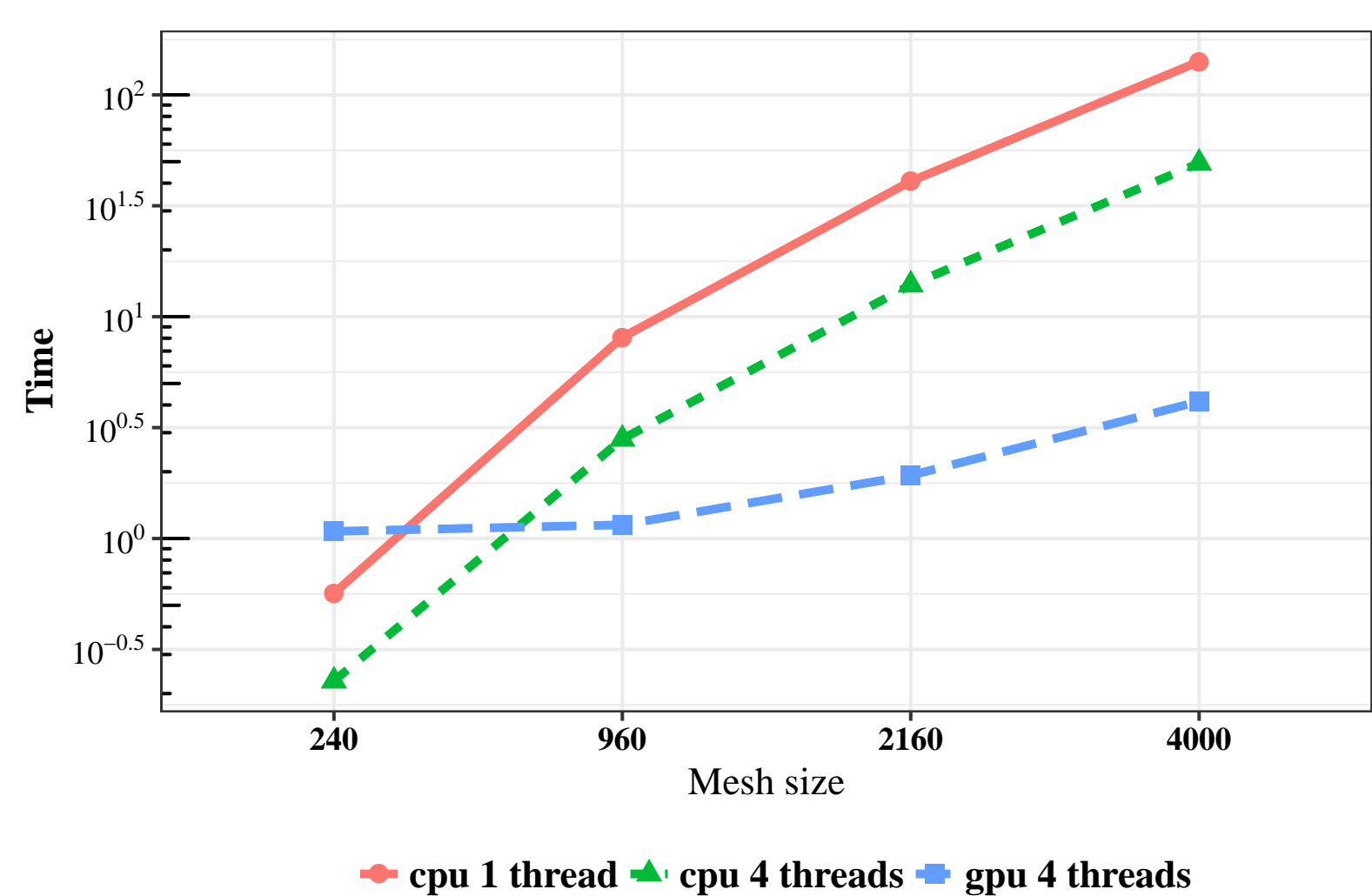

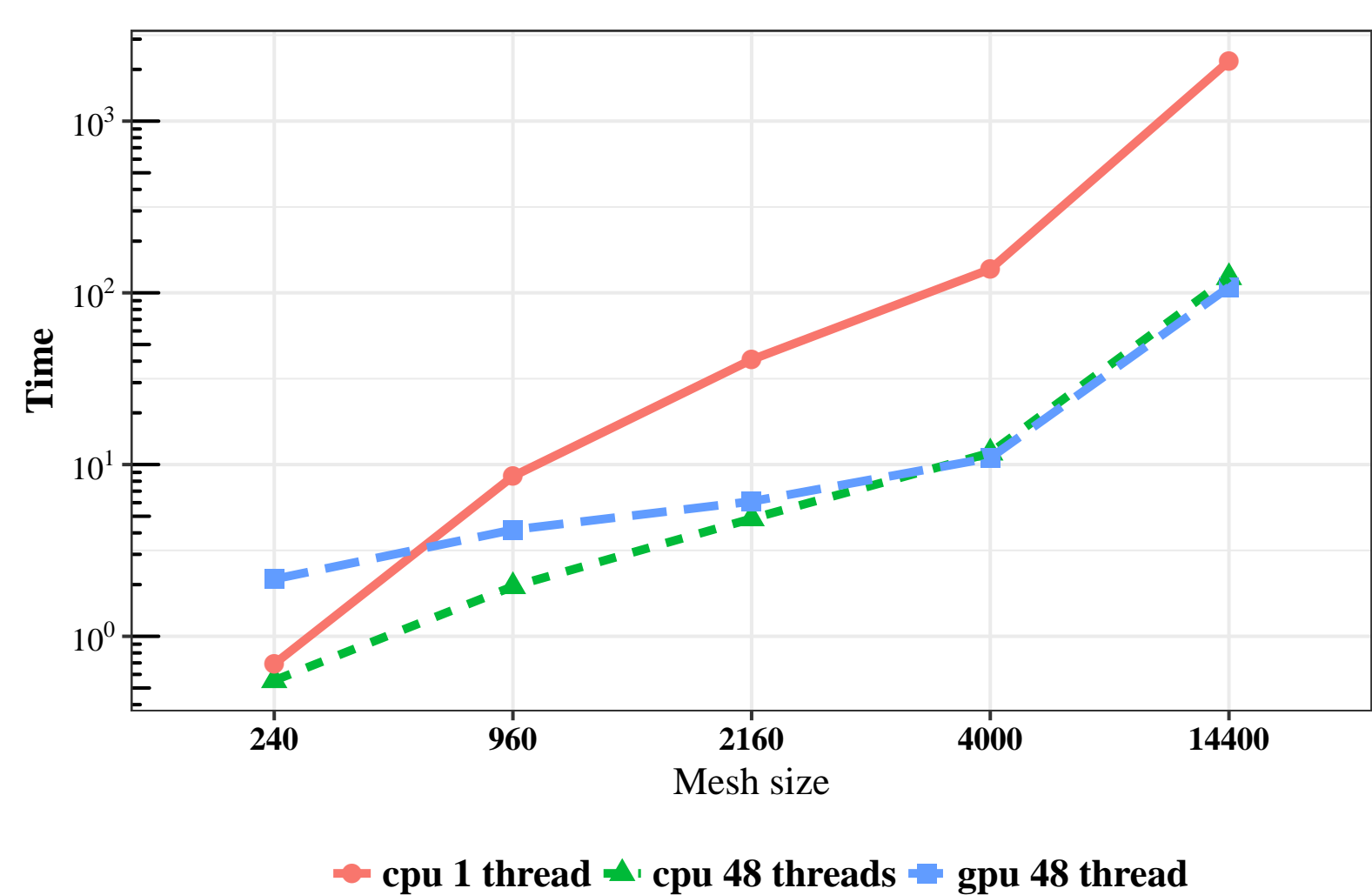Figure 2: Elapsed time in a `AMD A10-7700K` with a `GeForce GTX 980`

Figure 3: Elapsed time in a 2× `Xeon E6-2650 v4` with a `Tesla K40`

Conclusions

- Speedups of 3 (CPU) and 34 (GPU) in Figure 2
- Speedups of 18 (CPU) and 20 (GPU) in Figure 3
- Better speedups can be obtained if a load balancer is implemented

References

[1] John T Katsikadelis. *The Boundary Element Method for Engineers and Scientists: Theory and Applications.* Academic Press, 2016.

[2] Ronaldo Carrion. *Uma Implementa do Mdo dos Elementos de Contorno para problemas Viscoelastodincos Estacionos Tridimensionais em Domos Abertos e Fechados.* PhD thesis, Universidade Estadual de Campinas, 2002.

[3] Giuliano AF Belinassi, Rodrigo Siqueira, Ronaldo Carrion, Alfredo Goldman, and Marco D Gubitoso. Optimizing a boundary elements method for stationary elastodynamic problems implementation with gpus. *WSCAD-WIC 2017*, page 51.