Parallel Discrete Element Computations on Heterogeneous Resources

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KEYWORDS: *Discrete Element Method, Paallel Computing, Heterogeneous Resources, Clouds.*

ABSTRACT

The scalability, low cost and diversity of heterogeneous resources available through cloud providers encourage moving parallel applications, such as discrete element method (DEM) [1] computations of multi-physics granular flows, to clouds. However, heterogeneity of virtual cloud resources can cause severe degradation of parallel performance because of the irregular partitions for heterogeneous resources, limitations of memory bandwidth, communication overhead and increased load imbalance.

The presented resource-aware partitioning algorithm for heterogeneous cloud resources is distinguished by repartitioning condition defined by the skinning technique and granular flow physics. The parallel DEM code [2] was developed by using OpenCL for shared-memory multi-core computers and MPI for distributed-memory architectures. The DEM model for granular flows of the non-cohesive frictional visco-elastic spherical particles is implemented in the parallel software. The novel research on the parallel software performance was conducted in co-located cloud resources.

Six cases of heterogeneous resources, including GPU and co-located containers, were considered in the performed research. The speedup of parallel computations up to 6.0 was measured on 8 heterogeneous containers. The replacement of 3 faster containers by 3 slower ones slightly decreased the speedup up to 7.4% of the speedup measured on 5 homogeneous containers. Memory stress tests caused heterogeneity of non-isolated containers, which reduced the performance of memory bandwidth-bound DEM computaions on the co-located cloud resources. The decrease in the total execution time achieved by applying resource-aware repartitioning varied from 6.7% to 20.1% of the total execution time obtained without using weights, which depended on load imbalance. The resource-aware repartitioning decreased the computaion time on co-located containers when the synthetic stress was applied on one co-located container longer than 30% of the whole simulation time.

ACKNOWLEDGEMENT: Lithuanian-Polish joint research project “Multiscale modelling of physical properties of heterogeneous materials using X-Ray micro-CT testing” funded by the Lithuanian Academy of Sciences and the Polish Academy of Sciences.

REFERENCES

[1] P.A. Cundall, O.D.L. Strack, A discrete numerical model for granular assemblies, *Géotechnique*, Vol. 29, pp. 47-65, 1979.

[2] O. Bystrov, R. Pacevič, A. Kačeniauskas, Cost- and performance-aware resource selection for parallel software on heterogeneous cloud, *Concurr Comput Pract Exp*, e7877, 2024.