# **High Performance Computing 2023 - Exercise 1**

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### **Problem Statement**

A profiling study reports that **80**% of the total execution time of MPI applications is consumed by **MPI collective operations**.

#### This project aims to:

- Estimate the latency of the default OpenMPI implementation.
- Vary the number of processes and message sizes.
- Compare the results with other algorithms and process mappings.

## **Computational Resources**

- 2 THIN nodes from the ORFEO cluster.
- Each node has 2 CPUs with 12 cores in a single NUMA region.

More information: ORFEO cluster documentation.

## **Broadcast Algorithms**

#### Flat Tree Algorithm

- Single-level tree topology.
- Root node transmits to P-1 child nodes.

#### **Chain Tree Algorithm**

- Internal nodes have one child.
- Messages are split into segments, transmitted in a pipeline.

#### **Binary Tree Algorithm**

- Internal process has two children.
- Segmentation is used to improve communication parallelism.

# **Latency Analysis**

#### Latency vs Message Size (Fixed Processes)

- Scaling is linear across different message sizes.
- Observed consistent results across different process mappings.

#### Latency vs Number of Processes (Fixed Message Size)

- Different behaviors for small/medium and large message sizes.
- Mapping by core, socket, and node influences latency trends.

### **Performance Models**

Linear regression models were used to estimate the latency surface, varying the number of processes and message sizes.

#### **Results:**

- Core mapping shows better results for the linear algorithm.
- Binary Tree and Chain Tree algorithms perform similarly with node and socket mappings.

# **Barrier Algorithms**

### **Algorithms Analyzed:**

- Linear: All nodes report to a root.
- Tree: Hierarchical synchronization in a tree-like structure.
- Recursive Doubling: Logarithmic communication steps, optimal for powers of 2.

### Conclusion

- OpenMPI's default algorithm doesn't always choose the optimal one in terms of latency.
- However, differences in performance are often minor, making the default a reasonable choice in many cases.
- Custom mapping and algorithm selection can lead to performance improvements for specific configurations.

# **Appendix**

Refer to the 3D plots and latency vs process mappings in the appendix for detailed visual insights.