High Performance Computing assignment
Exercise 1

Piero Zappi

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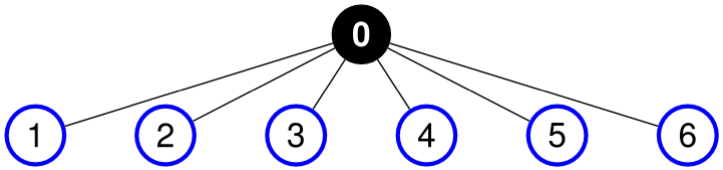
Objective

- Evaluate and compare the performance of various algorithms in the *OpenMPI* library for collective operations, focusing on **broadcast** and **barrier** operations.
- Develop prediction models to estimate the latency of these implementations.

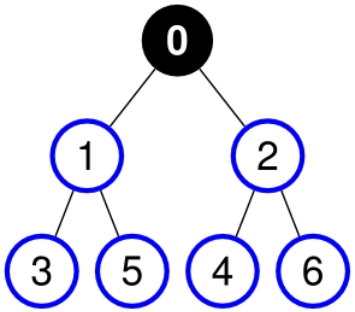
Experimental setup

- ORFEO cluster:
  - 2 **EPYC** nodes
  - 128 cores per node $\rightarrow$ 256 cores
- *OSU benchmark* for the analysis.
- **bash** scripts to automate the data collection process.
- **–map-by core** policy.
- Collect measures varying the number of processes from 2 to 256 and the size of the messages from 1 to 2^{17} bytes.

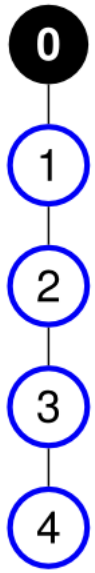
Broadcast - Algorithms



Flat tree

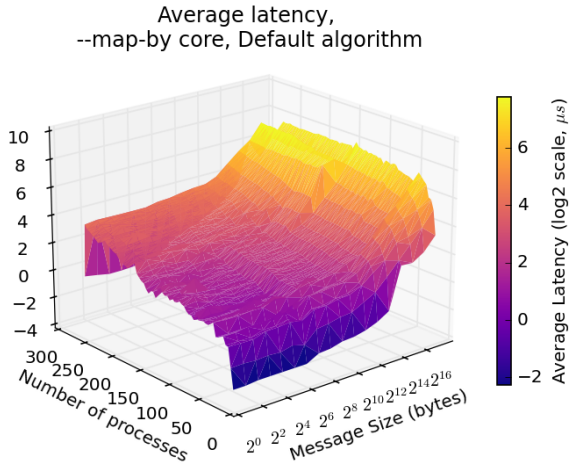


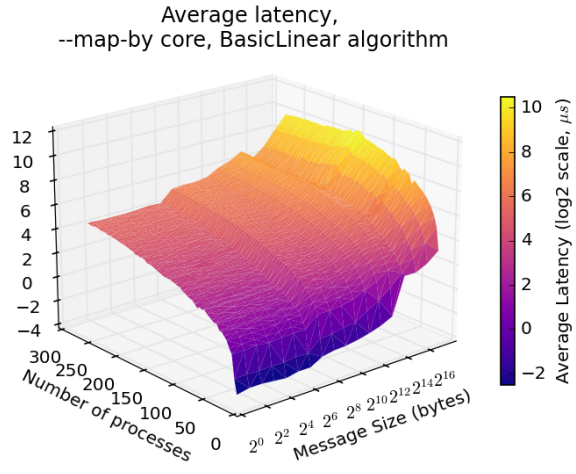
Binary tree

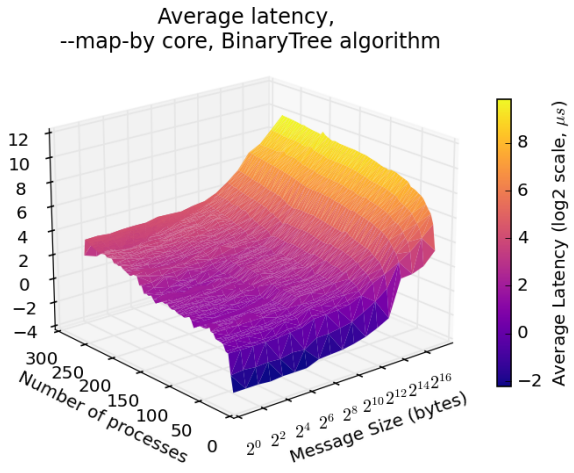


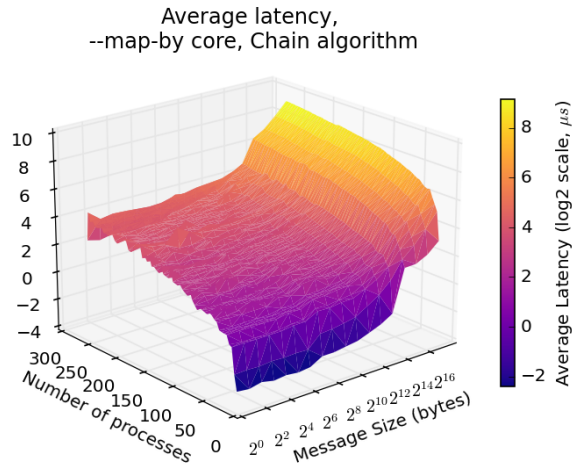
Chain

Broadcast - Average latency analysis
3D heatmaps

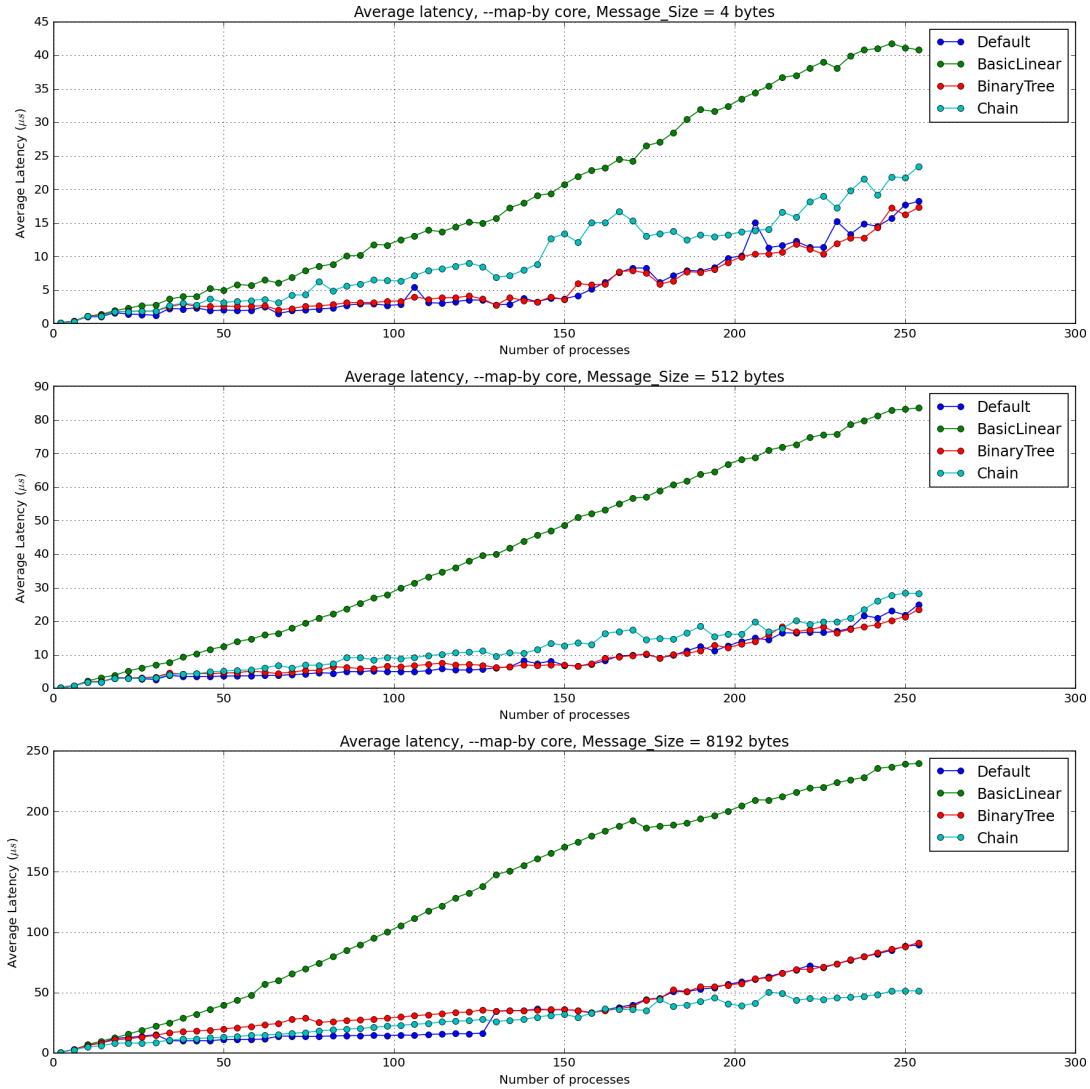








Broadcast - Average latency analysis
Latency fixing message sizes



Broadcast - Performance models

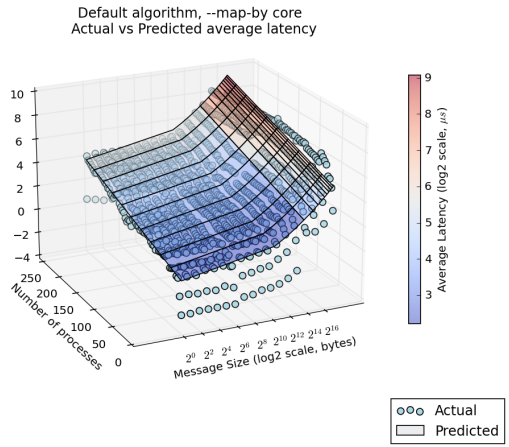
Models' structure:

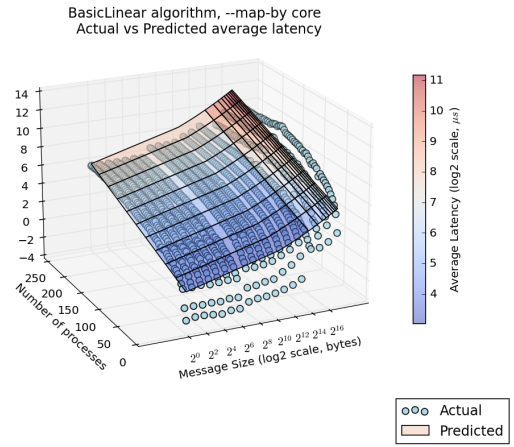
$$\log_2(\text{avg\_lat}) = \beta_1 * \text{proc\_num} + \beta_2 * \log_2(\text{mess\_size}) + \beta_3 * \log_2(\text{mess\_size})^2$$

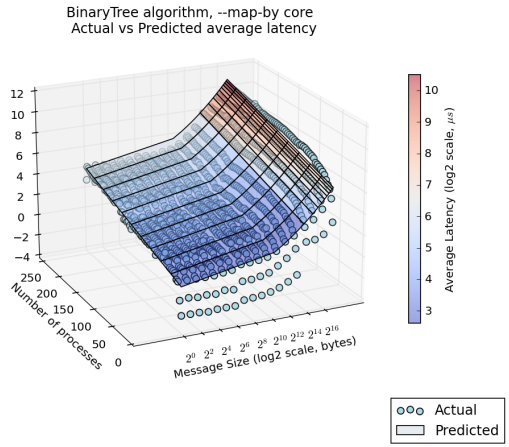
Models' summaries:

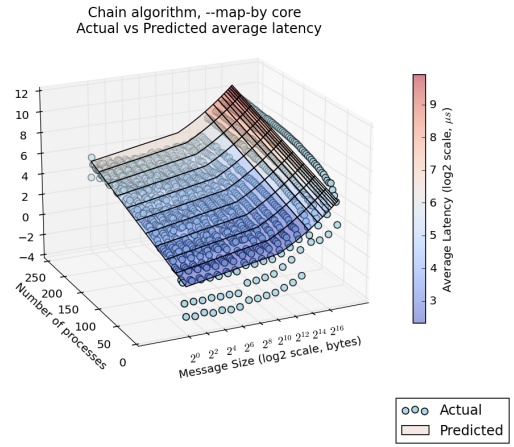
Algorithm	β_1	β_2	β_3	Adj. R^2
Default	0.0147	−0.1461	0.0278	0.970
Basic Linear	0.0215	0.0980	0.0148	0.970
Binary Tree	0.0155	−0.2100	0.0358	0.979
Chain	0.0182	−0.1212	0.0262	0.969

Broadcast - Performance models
Actual and predicted data

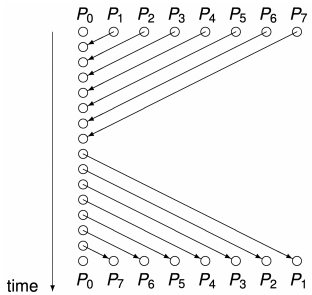




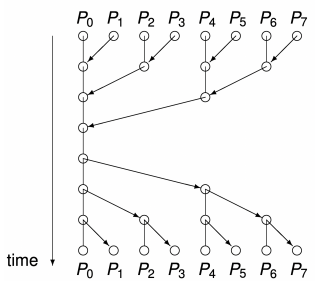




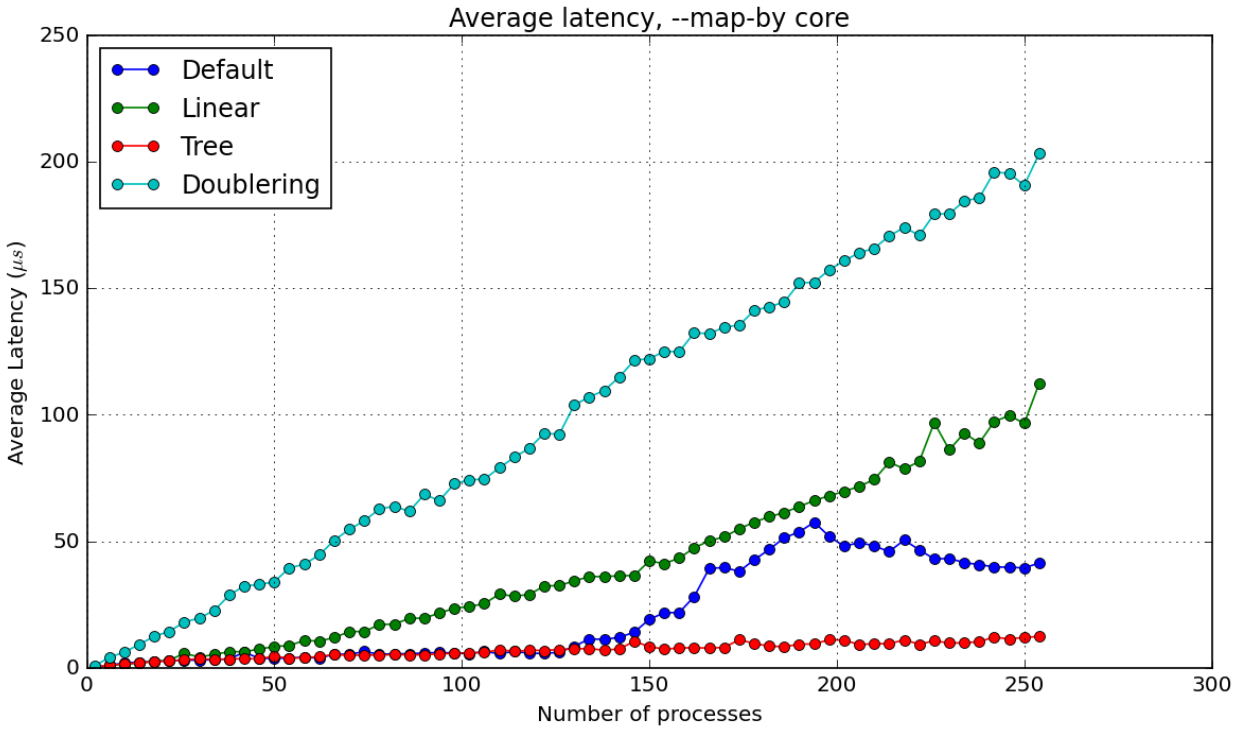
Barrier - Algorithms and average latency analysis



Linear



Tree



Barrier - Performance models

Model for linear algorithm ($x = \text{proc\_num}$):

$$\text{avg\_lat} = \beta_1 * x + \beta_2 * I(x > 128) + \beta_3 * (x * I(x > 128))$$

Model for tree algorithm:

$$\text{avg\_lat} = \beta_1 * \text{proc\_num} + \beta_2 * (\text{proc\_num})^2$$

Model for double ring algorithm:

$$\text{avg\_lat} = \beta_1 * \text{proc\_num}$$

Models' summaries:

Algorithm	β_1	β_2	β_3	Adj. R^2
Tree	0.0735	-0.0001	$--$	0.987
Linear	0.2301	-47.0331	0.3585	0.997
Double Ring	0.7853	$--$	$--$	0.999

Barrier - Performance models
Actual and predicted data