Analysis of algorithms implemented in OpenMPI collective operations

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Introduction

OpenMPI library implements blocking collective operations.
We will consider:

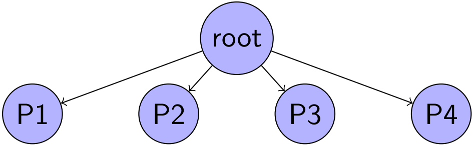
- `MPI_Bcast`
- `MPI_Reduce`

We will use the OSU Micro-Benchmark tool to evaluate the **latency** of these operations.
In particular, we are interested in analysis of these operation for different **algorithms**.

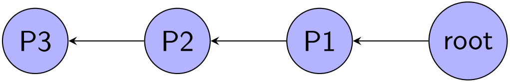
Algorithms

For both operations, we will analyze the following algorithms:

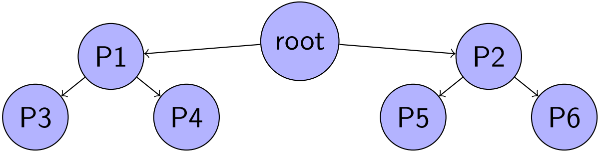
- Linear



- Chain



- (Split) Binary Tree



Computational resources

ORFEO cluster
THIN partition

- $10\times$ Intel Xeon Gold 6126
- 2×12 CPU cores each node
- 64 GiB of DDR4 RAM each core

For our analysis, we will use only 2 **THIN nodes**.

Other parameters

Beside **algorithm**, we will vary the other parameters as follows:

- **number of processes**: from 2 to 48 by step 2
- **mapping** of processes: by socket and by core
- **message length**: from $2^1, 2^2, \ldots 2^{19}, 2^{20}$ `MPI_Char`

For each configuration, we will perform 10^4 **repetitions** and compute the average latency of the operation.
Warm-up is performed.

Broadcast results

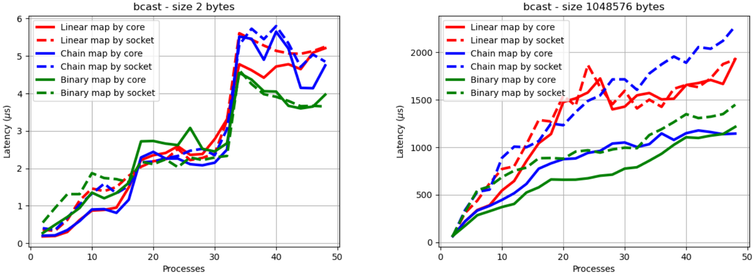


Figure: Broadcast average latency, for fixed message size of 2 bytes and 1 MB.

Broadcast results

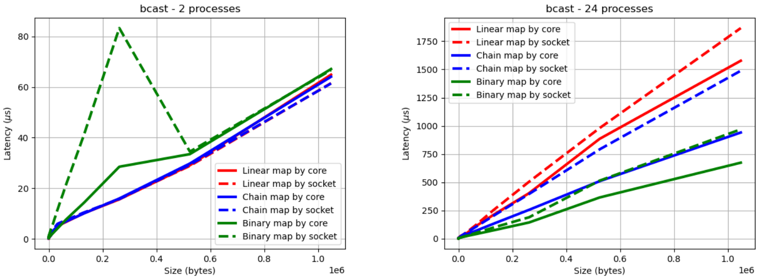


Figure: Broadcast average latency, for fixed number of processes: 2 and 24 .

Reduce results

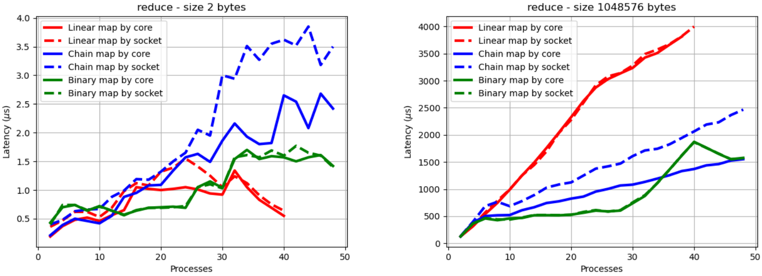
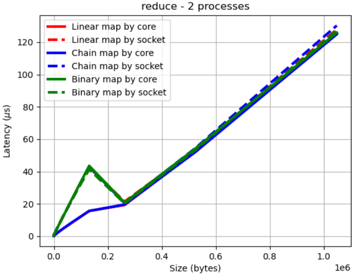


Figure: Reduce average latency, for fixed message Size: 2 and 24 .

Reduce results



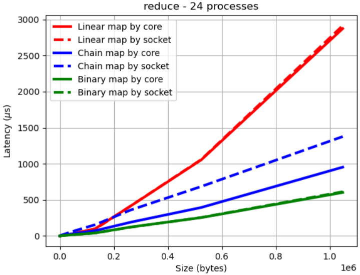


Figure: Reduce average latency, for fixed number of processes: 2 and 24 .

Linear regression - Bcast linear algorithm mapped by core

$$Latency = \beta_0 Processes + \beta_1 Size \tag{1}$$

	Coef.	Std. Err.	t	$P > \|t\|$	[0.025	0.975]
Processes	1.126	0.23	4.79	0.00	0.665	1.588
Size	0.001	0.00002	45.40	0.00	0.001	0.001

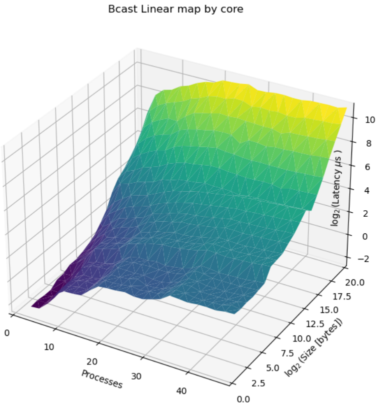
$R^2 = 0.84$ and $AIC = 6096$

$$\log_2 Latency = \beta_0 Processes + \beta_1 \log_2 Size \tag{2}$$

	Coef.	Std. Err.	t	$P > \|t\|$	[0.025	0.975]
Processess	0.027	0.004	6.69	0.00	0.019	0.035
log2_Size	0.325	0.0098	33.34	0.00	0.306	0.345

$R^2 = 0.88$ and $AIC = 1842$.

Conclusions



- Broadcast
  - If message size is large, split binary tree is the best choice.
  - Chain works better with core mapping.
  - logLatency is linear with logSize and number of Processes.
- Reduce
  - If message size is very small, linear algorithm is the best choice.
  - Mapping has no effect on the latency (except for Chain).