152117108 Advanced Computer Architecture

App. 3: MPI Communication Commands Review

Follow the instructions for parallel matrix summation in 2D (A+B = C).

1. MASTER creates *p*×*m* 2D dynamic array (*p*: machine, *m*: random constant).
2. Send rows of A and B to the processors.
   a. Send the rows of A by **MPI_Send** and **MPI_Recv**. MASTER can handle the first row directly.
   b. Share the rows of B by **MPI_Scatter,** root is MASTER.
3. For statistical purposes:
   a. The sum of column values of A is held by processing the local rows in each computer with **MPI_Allreduce**.
   b. The sum of column values of B is held by processing the local rows in each computer with **MPI_Reduce**, root is MASTER. And then share the results with each computer by **MPI_Bcast**.
4. Each node sums corresponding rows of A and B locally.
5. All local results are combined together in C by **MPI_Gather**, root is MASTER.

Example (4 machines):

```
------------- rank: 0 -------------
A (4x5):
|  8  0  9  1  6 |
|  4  8  3  5  5 |
|  8  2  4  8  9 |
|  2  4  5  2  9 |

B (4x5):
|  6  2  6  6  4 |
|  7  8  5  9  8 |
|  0  6  8  1  6 |
|  2  1  7  2  6 |

myRowA (1x5): [ 8  0  9  1  6 ]
myRowB (1x5): [ 6  2  6  6  4 ]
statsA (1x5): [22 14 21 16 29 ]
statsB (after reduce before bcast) (1x5): [15 17 26 18 24 ]
statsB (after bcast) (1x5): [15 17 26 18 24 ]
myRowC (1x5): [14  2 15  7 10 ]
C (4x5):
| 14  2 15  7 10 |
| 11 16  8 14 13 |
|  8  8 12  9 15 |
|  4  5 12  4 15 |

------------- rank: 2 -------------
myRowA (1x5): [ 8  2  4  8  9 ]
myRowB (1x5): [ 0  6  8  1  6 ]
statsA (1x5): [22 14 21 16 29 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [15 17 26 18 24 ]
myRowC (1x5): [ 8  8 12  9 15 ]
------------- rank: 1 -------------
myRowA (1x5): [ 4  8  3  5  5 ]
myRowB (1x5): [ 7  8  5  9  8 ]
statsA (1x5): [22 14 21 16 29 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [15 17 26 18 24 ]
myRowC (1x5): [11 16  8 14 13 ]
------------- rank: 3 -------------
myRowA (1x5): [ 2  4  5  2  9 ]
myRowB (1x5): [ 2  1  7  2  6 ]
statsA (1x5): [22 14 21 16 29 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [15 17 26 18 24 ]
myRowC (1x5): [ 4  5 12  4 15 ]
```

Example (6 machines):

```
------------- rank: 1 -------------
myRowA (1x5): [ 2  7  2  1  2 ]
myRowB (1x5): [ 7  6  1  7  4 ]
statsA (1x5): [19 22 28 24 10 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [49 20 32 29 26 ]
myRowC (1x5): [ 9 13  3  8  6 ]
------------- rank: 3 -------------
myRowA (1x5): [ 0  3  2  9  0 ]
myRowB (1x5): [ 9  0  7  9  5 ]
statsA (1x5): [19 22 28 24 10 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [49 20 32 29 26 ]
myRowC (1x5): [ 9  3  9 18  5 ]
------------- rank: 2 -------------
myRowA (1x5): [ 0  3  5  3  0 ]
myRowB (1x5): [ 9  7  5  1  0 ]
statsA (1x5): [19 22 28 24 10 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [49 20 32 29 26 ]
myRowC (1x5): [ 9 10 10  4  0 ]
------------- rank: 4 -------------
myRowA (1x5): [ 6  1  4  8  2 ]
myRowB (1x5): [ 8  3  9  9  3 ]
statsA (1x5): [19 22 28 24 10 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [49 20 32 29 26 ]
myRowC (1x5): [14  4 13 17  5 ]
------------- rank: 5 -------------
myRowA (1x5): [ 5  7  7  1  2 ]
myRowB (1x5): [ 9  0  1  0  5 ]
statsA (1x5): [19 22 28 24 10 ]
statsB (after reduce before bcast) (1x5): [-842150451 -842150451 -842150451 -842150451 -842150451 ]
statsB (after bcast) (1x5): [49 20 32 29 26 ]
myRowC (1x5): [14  7  8  1  7 ]
------------- rank: 0 -------------
A (6x5):
|  6  1  8  2  4 |
|  2  7  2  1  2 |
|  0  3  5  3  0 |
|  0  3  2  9  0 |
|  6  1  4  8  2 |
|  5  7  7  1  2 |

B (6x5):
|  7  4  9  3  9 |
|  7  6  1  7  4 |
|  9  7  5  1  0 |
|  9  0  7  9  5 |
|  8  3  9  9  3 |
|  9  0  1  0  5 |

myRowA (1x5): [ 6  1  8  2  4 ]
myRowB (1x5): [ 7  4  9  3  9 ]
statsA (1x5): [19 22 28 24 10 ]
statsB (after reduce before bcast) (1x5): [49 20 32 29 26 ]
statsB (after bcast) (1x5): [49 20 32 29 26 ]
myRowC (1x5): [13  5 17  5 13 ]
C (6x5):
| 13  5 17  5 13 |
|  9 13  3  8  6 |
|  9 10 10  4  0 |
|  9  3  9 18  5 |
| 14  4 13 17  5 |
| 14  7  8  1  7 |
```