Lecture: Distributed Memory Machines and Programming
-- MPI programming exercise

CSCE 569 Parallel Computing

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Machines and MPI Examples

- Machines in Swearingen 1D39 and 3D22
  - https://passlab.github.io/CSCE569/resources/HardwareSoftware.html
- MPI Examples:
  - https://passlab.github.io/CSCE569/resources/mpi_examples/
  - wget https://passlab.github.io/CSCE569/resources/mpi_examples/mpihello.c

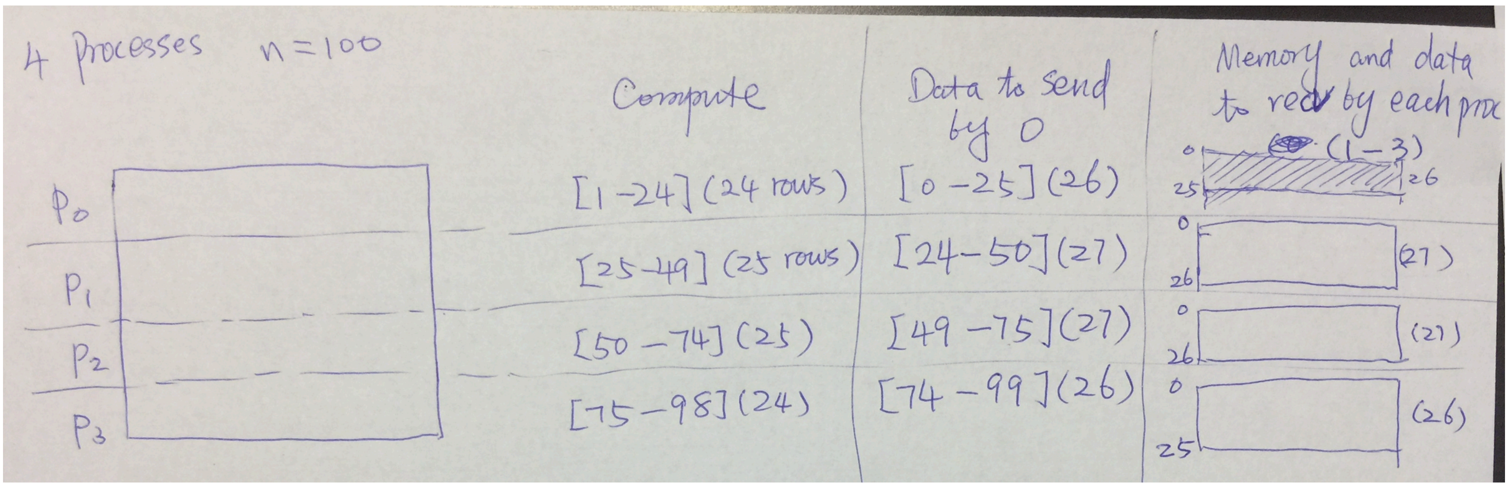
- mpicc mpihello.c -o mpihello
- mpirun -np 2 ./mpihello

Jacobi in Assignment #3

- TODO #1: Row-wise data distribution
- TODO #2: Jacobi computation
  a) Update begin and end of the loop index variable
  b) Boundary (ghost region) exchange
  c) Reduction for error
- TODO #3: Data collection, opposite of TODO #1

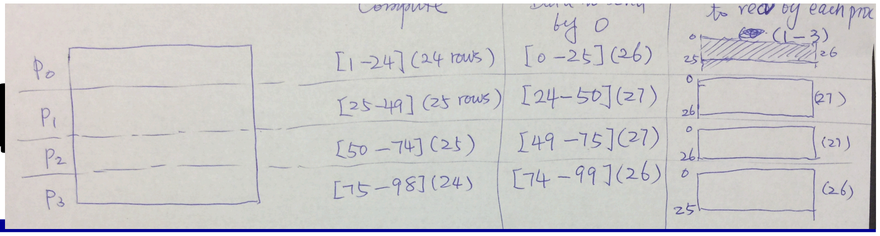
TODO #1: Row-wise data distribution

- numprocs = 4 (4 MPI processes) and n = 100
  - n is divisible by numprocs
  - How u should be distributed into subarray and computed by each MPI process



  - Processes 0 and numprocs-1 each has only one neighbors and each other process has two neighbors (top and bottom)
  - The same for u and f
    - To make programming easier in TODO #2

TODO #1: Row-wise d



- Process 0 has initial array and data for the full u and f
- 0 uses MPI_Send to send subarray of u and f to each other process
  - Calculate num_rows to send for each other process
    - If other is 1 to numprocs-2: n/numprocs + 2
    - If other is numprocs-1: n/numprocs + 1
  - Calculate pointer of the subarray data region for each other process
    - other is 1 to numprocs-1: u + (**other***n/numprocs -1)*m
- Other processes use MPI_Recv to receive u and f subarray
  - Calculate num_rows to recv from process 0
    - If myrank is 1 to numprocs-2: n/numprocs + 2
    - If myrank is numprocs-1: n/numprocs + 1
  - Allocate memory to store subarray data received from 0
- Make sure the tag for Send/Recv pair are the same and correct.

TODO #3: Row-wise data collection

- Process will have final result for the full u
  - No need to collect f
- 0 uses MPI_Recv to recv subarray of u from each other process
  - Calculate num_rows to recv for each other process
    - If other is 1 to numprocs-2: n/numprocs + 2
    - If other is numprocs-1: n/numprocs + 1
  - Calculate pointer for storing the subarray data recved from each other process
    - other is 1 to numprocs-1: u + (**other***n/numprocs -1)*m
- Other processes use MPI_Send to send u subarray
  - Calculate num_rows to send to process 0
    - If myrank is 1 to numprocs-2: n/numprocs + 2
    - If myrank is numprocs-1: n/numprocs + 1
  - Deallocate memory for the subarray
- Make sure the tag for Send/Recv pair are the same and correct.

TODO #2: Jacobi computation

- TODO #2:
  a) Update begin and end of the loop index variable
  b) Boundary (ghost region) exchange
  c) Reduction for error

a) Row-wise distribution

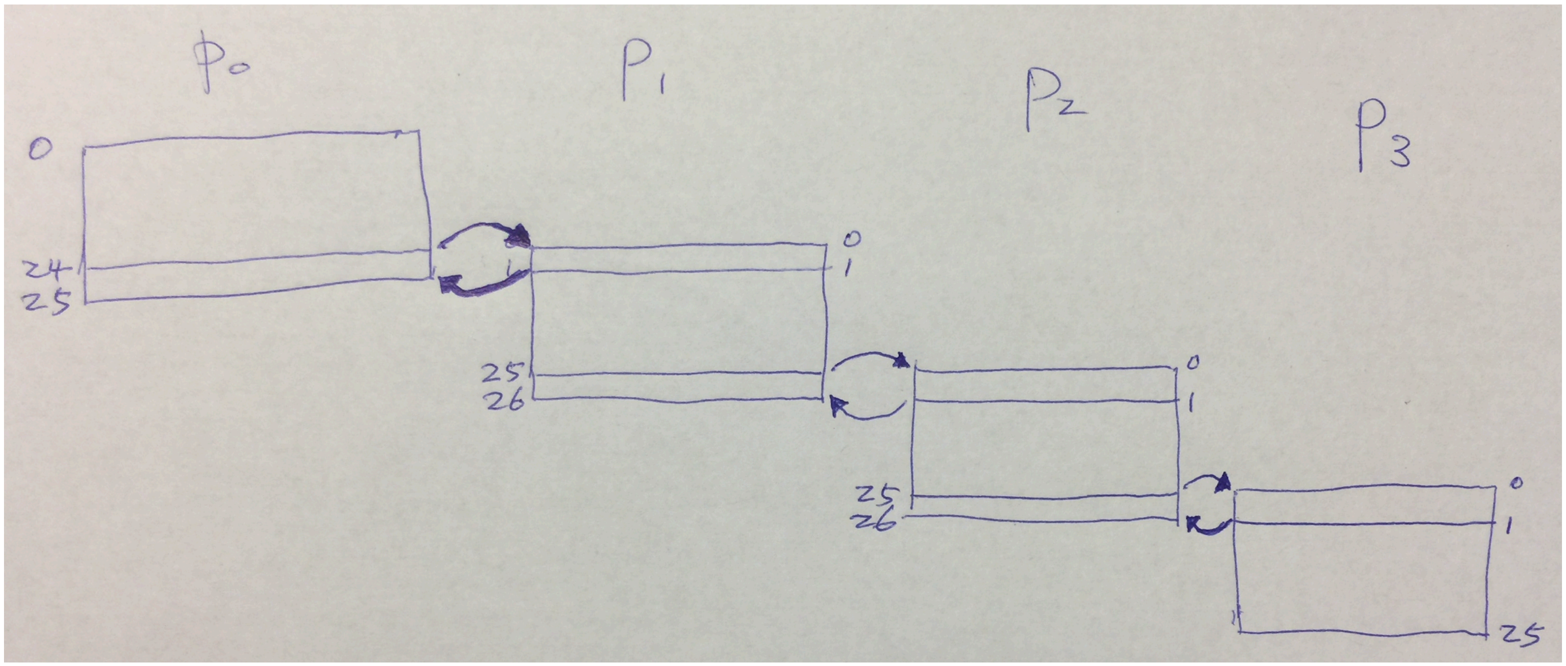
– i is 1 to num_rows - 1

TODO #2: Jacobi computation

b) Boundary exchange using MPI_Send/Recv

- 0: MPI_Send row num_rows-2 to proc 1, MPI_Recv row num_rows-1 from proc 1
- 1: MPI_Recv row 0 from 0 (myrank-1), MPI_Send row 1 to 0 (myrank-1)
- 1. MPI_Send row num_rows-2 to myrank+1, MPI_Recv row num_rows-1 from myrank+1
- ...
- num_procs-1: MPI_Recv row 0 from myrank-1, MPI_Send row 1 to myrank -1

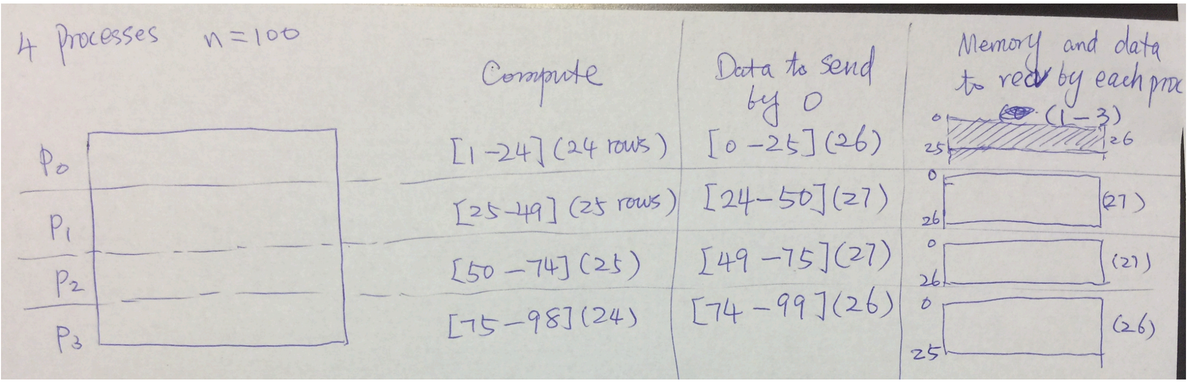
- Make sure the tag for Send/Recv pair are the same and correct.



TODO #2: Jacobi computation

c) Reduction for error

- Local_error computed by each process
- Sum up local_error to have error and then broadcast to all processes



- MPI_Allreduce(&local_error, &error, 1, MPI_FLOAT, MPI_SUM, COMM_WORLD);

TODO #2: Optimizing Jacobi computation

b) Boundary exchange optimization

- Currently solution serializes message passing for exchange
  - 0, 1, 2, 3, …
- Using MPI_Isend/Irecv to have parallelized exchange
  - MPI_Wait after firing Isend/irecv, before computation
- Overlap comm and computation
  - MPI_Wait after the computation loop, but before the MPI_Allreduce for error