Parallel Bubble Sort in MPI

- To run the program, run makefile using

```
make np=<num_of_processors_required>
e.g. make np=10
```

- Input is stored in **input.txt** with format as

```
num_of_elems,elem_1,elem_2,.....,elem_n
```

- If you get an error like

```
There are not enough slots available in the system
to satisfy the xxx slots that were requested by the
application:
Either request fewer slots for your application,
or make more slots available for use.
```

  - Just type echo "localhost slots=< a number bigger than xxx >" > hostfile
  - Rerun make, it should work now

Algorithm applied

- The program divides number of elements equally to processors
  - i.e. with n elements and p processors, each processor gets n/p elements
- Each processor sequentially sorts its n/p elements using merge sort
- Then the processors do odd-even transposition sort

```
for p phases do

    if phase is odd begin
        odd rank processors exchange data
        with thier next processor and keep lower elements
    end

    else begin
        even rank processors exchange
        with their next processors and keep lower elements
    end

endfor
```

Theoretical speedup possible

- Time complexity of serial execution
  - n = to take input
  - 3n(n-1)/2 = for sorting
  - which is O(n^2)
- Time complexity of parallel execution
  - n = to take input
  - O(n/p log(n/p)) - for locally sorting using merge sort
  - p*(2*n/p{for send/rcv operation} + 2n/p {picking lower/higher elements} + communication costs) = O(n) if we ignore communication costs
  - which is O(n) if p ~ n
- Therefore, theoretical speedup = O(n^2) / O(n) = n

Actual speedup

- For Input size = 40000
  - np = 2, seq time = 2.546008, parallel time = 0.029484, speedup = 86.3529
  - np = 5, seq time = 2.929127, parallel time = 0.048237, speedup = 60.7239
  - np = 10, seq time = 3.222945, parallel time = 1.496682, speedup = 2.143394
- Mismatch in experimental and actual speedup may be because of increasing communication costs while increasing the number of processors. (Since, we have ignored the communication costs in analysis)

Dependencies

- OpenMPI
  - To install run command `sudo apt install openmpi-bin`