Laboratory for Parallel Programming
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Large-Scale Parallel Computing (WS 15/16)

Exercise 4

This is a hands on exercise. The solution will be developed by the tutor and the students together in the class on December 8th, 2015. However, the students are encouraged to solve the problem before attending the session.

Task 1

The exercise involves making a parallel version of a NEWS median filter and applying it on an ASCII PGM image file. The NEWS filter is a median filter used in image processing for removing salt and pepper noise from images. See exercise 2 for a description of the median filter, and the problem related to its data distribution among multiple processes.

A serial version of the filter, along with a sample image is provided with the exercise in the `ex04.tgz` archive. The archive can also be copied from `/home/as65huly/public/ex04.tgz` on the Lichtenberg cluster.
Copy the archive to a folder of your choice on the Lichtenberg cluster. Use the `Makefile` to compile the `pgm_NEWS_filter.c` file. To run the program, use `./pgm_NEWS_filter <input_image_file_name> <output_image_file_name>`.

To view the image files, use the `display` command on the Lichtenberg cluster. However, as the image in the PGM format can have a very large size, it is recommended to first convert the image to JPEG format before displaying it. Use `convert <image_name.pgm> <image_name.jpg>` to convert the image to JPEG format. Then use `display <image_name.jpg>` to display the image.
Note: to display the image, connect to the Lichtenberg cluster with `-Y` option when using the `ssh` command. Example: `ssh -Y <tu_id>@lcluster2.hrz.tu-darmstadt.de`. If you are using a Mac, make sure you have installed XQuartz, while if you are using Windows, install Cygwin/X, before running the `ssh` command. Linux systems do not need any additional software.

The `ex04.tgz` archive also contains the simple `helloworld.c` MPI program. In the program, each process prints `hello world`, along with its rank and the total number of processes. This program is provided as a basic learning program. The `Makefile` also compiles the `helloworld.c` MPI program. The archive also contains a batch script (`job_helloworld.sh`) that submits the job to the cluster for execution. Use the file to submit the program. The output of the program is written to a file in the `logs` directory. **Note: change the email address in the batch script before submitting the script.**

To write programs on the Lichtenberg cluster, you can use the `vim` editor, or any other editor of your choice. If you prefer to have a GUI, you can use the `vim` program in the `ex04.tgz` archive with a `-g` option. The command will look like this `./vim -g`. **Note:** the `./` option is necessary, otherwise the system default `vim` application will be executed, which does not accept `-g` option. Also, you must have installed Cygwin/X on Windows or XQuartz on Mac for the GUI to appear. Linux systems do not need any additional software.

Now implement an MPI version of the `pgm_NEWS_filter.c` program by following these steps.

a) Initialize MPI at the beginning and get process rank and communicator size.

b) Rank 0 process reads the PGM file.

c) Rank 0 broadcasts the image height, width and maximum color.

d) Rank 0 then scatters the image data among the processes.

e) Additionally, a separate mechanism is implemented to distribute the bordering rows of each process's image chunk.

f) Apply the NEWS filter.

g) Gather the data back at rank 0 process.

h) Rank 0 process writes the image back to a new file.