

Image Processing

A case study for a domain decomposed MPI code



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Domain Decomposition 1

- Starting with a big array:



Domain Decomposition 2

- Split it into pieces:



Domain Decomposition 3

- Assign pieces to processors:



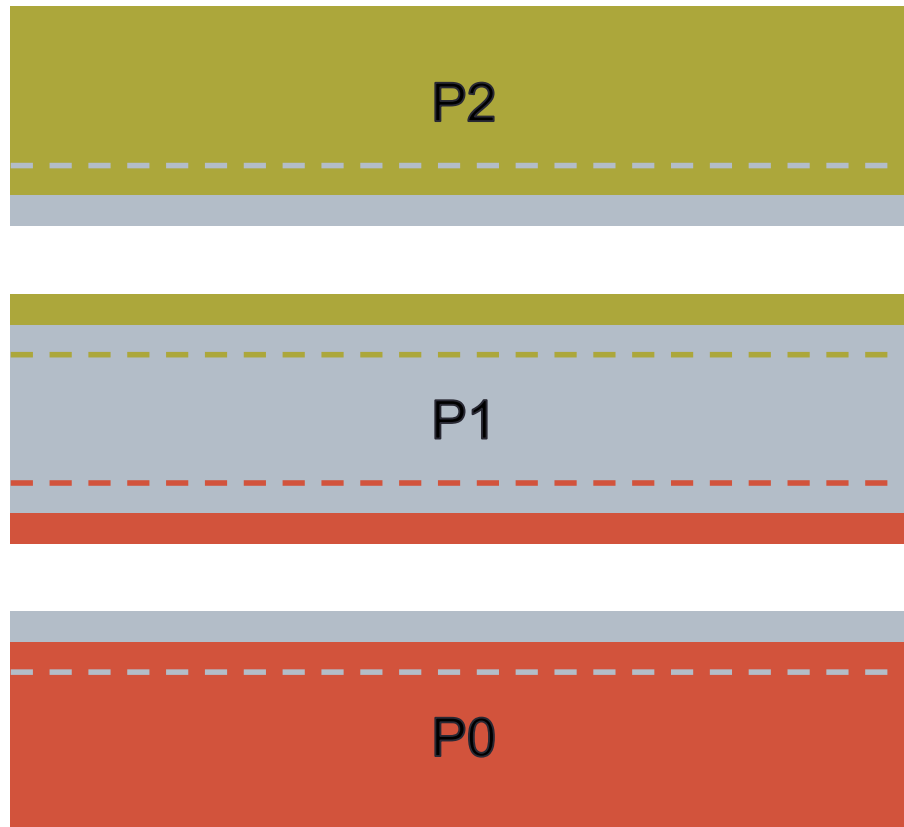
P2

P1

P0

Domain Decomposition 4

- Use Halos to deal with nearest-neighbour interactions

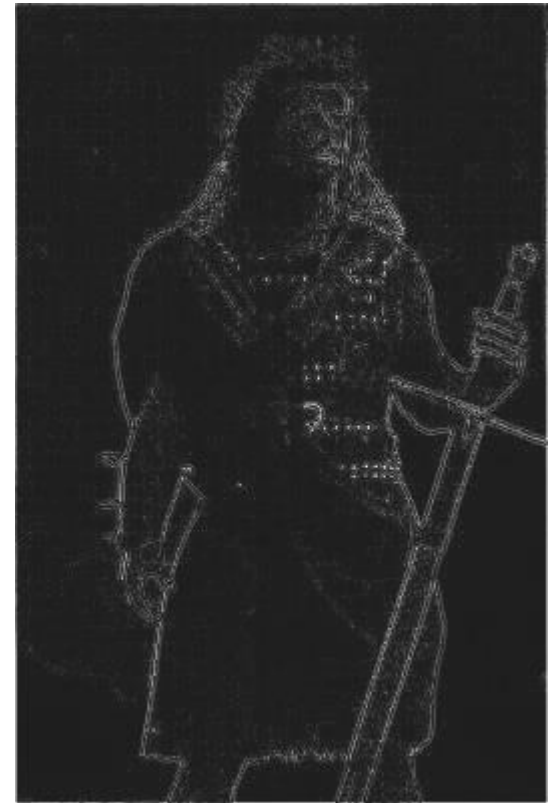


Edge detection / image reconstruction



single
pass

hundreds of
iterations



Edge detection

- Compare pixel to its four nearest neighbours
 - pixel values are from 0 (black) to 255 (white)

$$edge_{i,j} = image_{i+1,j} + image_{i,j+1} + image_{i-1,j} + image_{i,j-1} - 4 image_{i,j}$$

- What about the boundary conditions?
 - use non-periodic boundaries
 - pixels off the edge of the image (e.g. $image_{M+1,j}$) are set to white
- Pad 2D arrays with halos
 - in serial code, all halo values set to 255 (i.e. white)

Image reconstruction

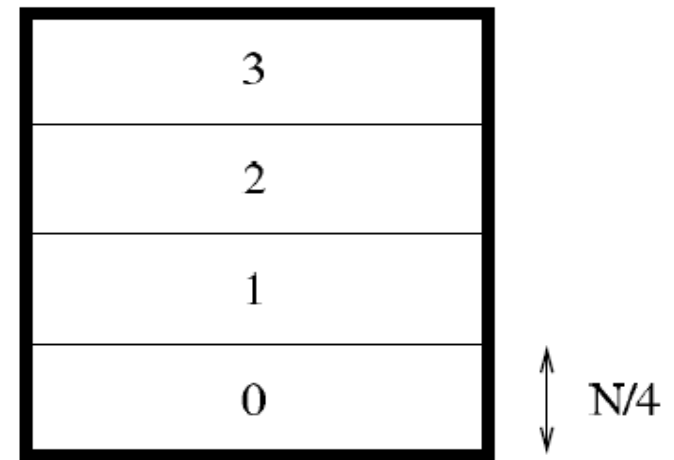
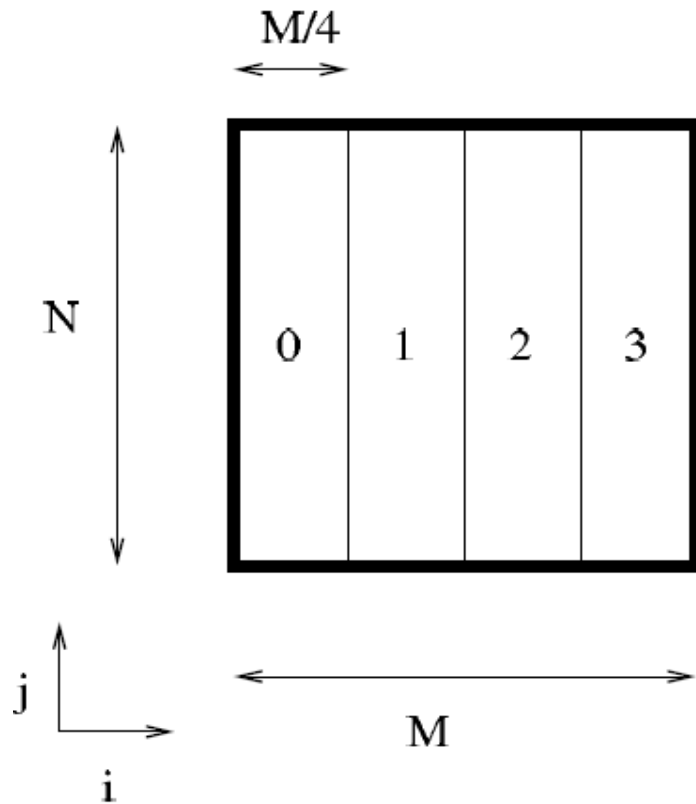
- Jacobi Solver to undo the simple edge detection algorithm (a five-point stencil)
 - simple example of discretised partial differential equation with nearest-neighbour interactions
 - actually solving $\nabla^2 image = edge$

$$new_{i,j} = \frac{1}{4} (old_{i+1,j} + old_{i-1,j} + old_{i,j+1} + old_{i,j-1} - edge_{i,j})$$

- Repeat many times
 - in parallel, must update halo values from neighbours every iteration

Domain Decomposition

- Different choices in C and Fortran



The case study

- I provide you with:
 - More detailed printed instruction
 - Tar-ball (Choice of C or Fortran)
 - Input routine
 - Output routine
 - Couple of input files
- Tasks
 - Write a serial code (with halos for fixed boundary conditions)
 - ***check that the serial code works!!***
 - Distribute the work onto the processors; separate reconstructions
 - Get the halos exchanged; single reconstruction, identical to serial
 - Further suggestions on the instruction sheet

Viewing the Images

- Images are in a very old-fashioned text-based format
 - Portable Grey Map (PGM)
 - easy to read and write
- Should be able to view directly from EPCC machines

```
user@epcc:~> display image.pgm
```

- You may not be able to view PGM files on your laptop
 - could install *ImageMagick* suite (which contains *display*)
 - try converting format on EPCC system first, e.g. to a PNG file:

```
user@epcc:~> convert image.pgm image.png
```