

# Image Processing

---

A case study for a domain decomposed MPI code

# Reusing this material



This work is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

<http://creativecommons.org/licenses/by-nc-sa/4.0/>

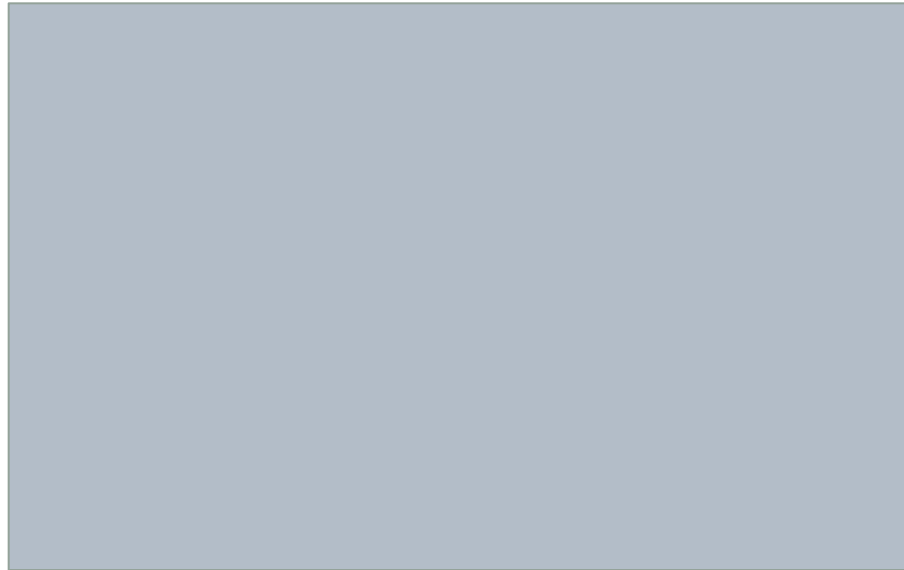
This means you are free to copy and redistribute the material and adapt and build on the material under the following terms: You must give appropriate credit, provide a link to the license and indicate if changes were made. If you adapt or build on the material you must distribute your work under the same license as the original.

Acknowledge EPCC as follows: “© EPCC, The University of Edinburgh, [www.epcc.ed.ac.uk](http://www.epcc.ed.ac.uk)”

Note that this presentation contains images owned by others. Please seek their permission before reusing these images.

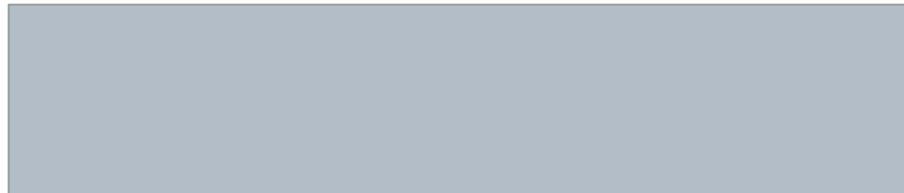
# Domain Decomposition 1

- Starting with a big array:



# Domain Decomposition 2

- Split it into pieces:



# Domain Decomposition 3

- Assign pieces to processes:



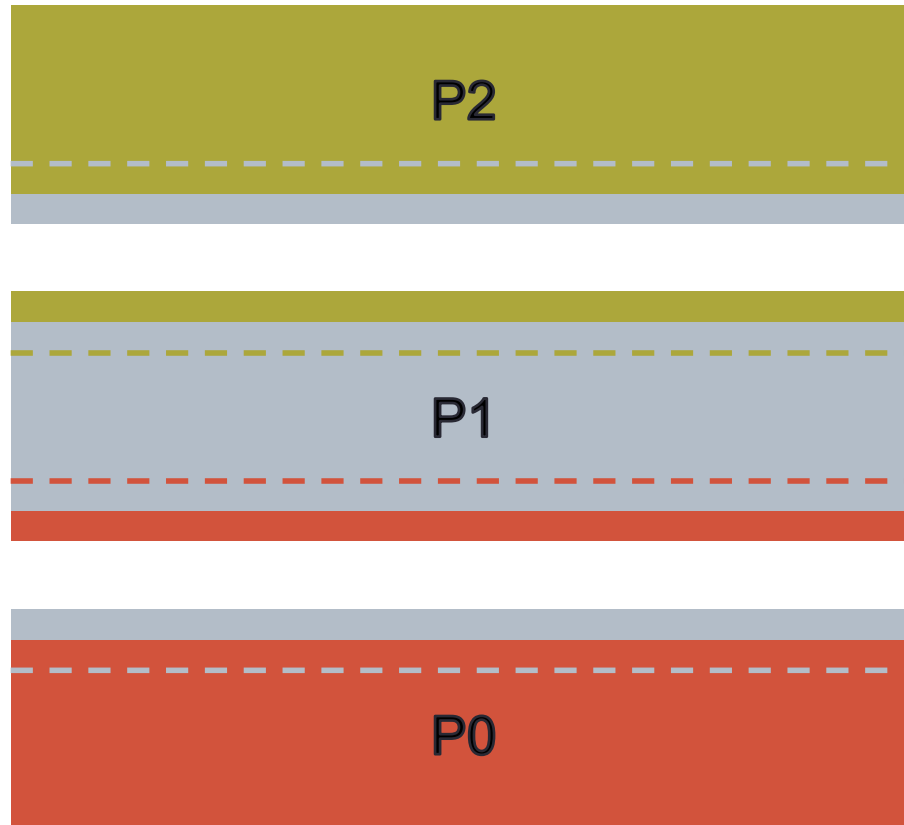
P2

P1

P0

# Domain Decomposition 4

- Use halos to deal with nearest-neighbour interactions

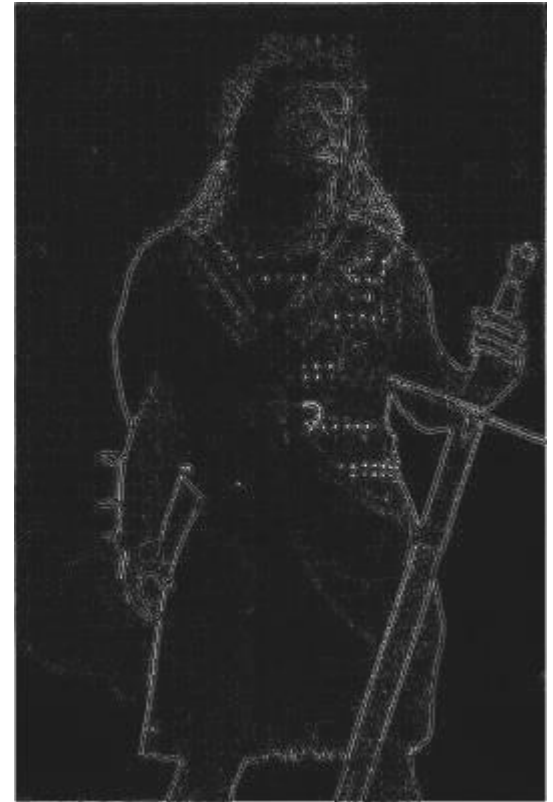


# Edge detection / image reconstruction



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

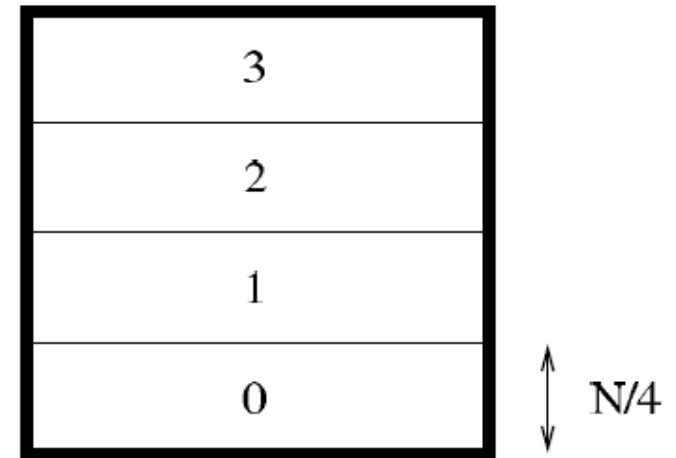
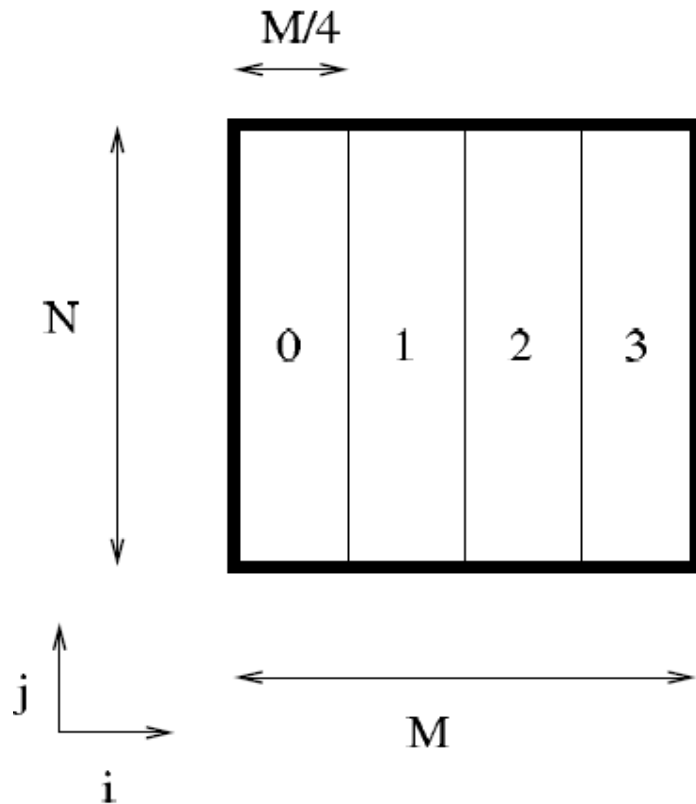
- Jacobi Solver to undo the simple edge detection algorithm (a five-point stencil)
  - simple example of discretised partial differential equation with nearest-neighbour interactions
  - actually solving  $\nabla^2 image = edge$

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

- 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
- You may not be able to view PGM files on your laptop
  - could install *ImageMagick* suite (which contains *display*)
    - `user@laptop:~> display image.pgm`
  - may have problems with the input edge files (contain negative values!)
    - `user@laptop:~> sed 's/\-//g' edge.pgm | display -`
- Viewing on Cirrus / ARCHER2 (wrapper script round *display*)
  - fixes the potential issue with negative values
    - `user@cirrus:~> module load ImageMagick`
    - `user@archer2:~> module load imagemagick`
    - `user@archer2:~> pgmdisplay image.pgm`