# Assignment MPI: 2D Heat Equation

The purpose of this assignment is for you to learn more about

- implementing operations using regular communication patterns.
- the impact of data partitioning.

As usual all time measurements are to be performed on the cluster.

**Strong scaling experiment.** An experiment is a strong scaling experiment when you measure the speedup an algorithm achieves when you increase the number of resources. All the experiments we conducted so far were strong scaling experiments. Usually these are reported using a speedup chart.

**Weak scaling experiment.** An experiment is a weak scaling experiment when you increase the computational requirement of the problem proportionally to the number of resources allocated to the problem. Usually these are reported using a (processor,time) chart. The computation scales if the curve is flat.

## 1 2D heat equation (50 pts)

The problem is defined on a discrete 2D space of size $n \times n$; let's call it $H$. Initialize $H$ using the provided functions. The $k$th iteration of the heat equation is defined by $H^k$ is defined by

$$H^k[i][j] = \frac{1}{5}(H^{k-1}[i-1][j] + H^{k-1}[i][j-1] + H^{k-1}[i][j] + H^{k-1}[i][j+1] + H^{k-1}[i+1][j])$$

(Take the elements out of the array as being $H^{k-1}[i][j]$)

Note that the implementation probably needs to keep $H^k$ and $H^{k-1}$ in memory.

**Question:** Implement a distributed memory version of the 2D heat equation problem. Write the code in `heat/mpi_heat.cpp`. Partition the data in blocks similarly to the matrix multiplication case.

(Hint: implement it sequentially first.)

**Question:** Perform a strong and weak scaling experiment to compute $H^5$. Use `make bench`.

**Question:** plot results with `make plot`. Does the code scale strongly? Does the code scale weakly?

**Question:** Describe how you would increase communication and computation overlap? (No need to write that code, just describe how you would achieve that.)