

**PROGRAMACIÓN PARALELA**  
**Basic OpenMP + MPI – Exercises**

1.- In a previous example we estimated the value of  $\pi$  by means of approximating the integral of  $4 / (1 + x^2)$  using tangent-trapezoidal rule and  $n$  trapezoids.

Modify the sequential version of the program so that each thread in an OpenMP approach adds  $n/p$  intervals, and the distance between intervals is equal to 1. Keep in mind, that typically, the number of threads is a power of 2. Besides, use values of  $n$  that are powers of 2 also. To do so, define two variables: `lwr_lim` and `upr_lim` that denote, respectively, the lower and upper limits of the interval corresponding to each thread.

2.- Combine the result obtained for a MPI point-to-point solution using a binomial tree with the developed OpenMP approach.

3.- Develop a function that calculates the dot product of two vectors of any length. Then, parallelise it using OpenMP. Finally, combine the solution with a MPI point-to-point solution using a binomial tree.

4.- Modify the parallel version of the previous solution so that it better exploits the vector units available in the processor(s) you are currently using.