The Compute : Communicate Ratio

Intracore computing
Intercore communication

Compute : Communicate ratio = $N : 2$
where $N$ is the number of compute cells per core

In the above drawing, Compute : Communicate is 4 : 2

How do more Cores Interact with the Compute-to-Communicate Ratio?

In this case, with 4 cores, Compute : Communicate = 4 : 2

Think of it as a Goldilocks and the Three Bears sort of thing. :-)
Too little Compute : Communicate and you are spending all your time sharing data values across threads and doing too little computing.

Too much Compute : Communicate and you are not spreading out your problem among enough threads to get good parallelism.

It’s difficult to find the “sweet spot” without running experiments.

Performance as a Function of Number of MPI Processors

Performance as a Function of NUM_ELEMENTS

Performance as a Function of Number of Cores
2D Heat Transfer Equation

\[ \rho \alpha^2 \frac{\partial T}{\partial t} = \frac{\partial}{\partial x} \left( k \frac{\partial T}{\partial x} \right) + \frac{\partial}{\partial y} \left( k \frac{\partial T}{\partial y} \right) \]

\( \Delta T \frac{\partial T}{\partial t} = \frac{k}{\rho \alpha} \left( \frac{\partial T_i}{\partial x} + \frac{\partial T_i}{\partial y} \right) \]

3D Heat Transfer Equation

\[ \rho \alpha^2 \frac{\partial T}{\partial t} = \frac{\partial}{\partial x} \left( k \frac{\partial T}{\partial x} \right) + \frac{\partial}{\partial y} \left( k \frac{\partial T}{\partial y} \right) + \frac{\partial}{\partial z} \left( k \frac{\partial T}{\partial z} \right) \]

\( \Delta T \frac{\partial T}{\partial t} = \frac{k}{\rho \alpha} \left( \frac{\partial T_i}{\partial x} + \frac{\partial T_i}{\partial y} + \frac{\partial T_i}{\partial z} \right) \]

2D Compute-to-Communicate Ratio

\[ \text{Compute : Communicate ratio} = \frac{N_1^2}{4N} = \frac{N}{4} \]

where \( N \) is the dimension of compute nodes per core

In 2D the Compute : Communicate ratio is sometimes referred to as 
Area-to-Perimeter

3D Compute-to-Communicate Ratio

\[ \text{Compute : Communicate ratio} = \frac{N_1^3}{6N} = \frac{N}{6} \]

where \( N \) is the dimension of compute nodes per core

In 3D the Compute : Communicate ratio is sometimes referred to as 
Volume-to-Surface