The Compute : Communicate Ratio
1D Compute-to-Communicate Ratio

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 if 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 Nodes

MegaNodes Computed Per Second

# of Nodes to Compute

# of Threads
Performance as a Function of Number of Threads

MegaNodes Computed Per Second

# of Threads

# of Nodes
2D Heat Transfer Equation

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

\[ \Delta T = \frac{k}{\rho C} \left( \frac{\Delta^2 T}{\Delta x^2} + \frac{\Delta^2 T}{\Delta y^2} \right) \]

\[ \Delta T_{i,j} = \left( \frac{k}{\rho C} \right) \left( \frac{T_{i-1,j} - 2T_{i,j} + T_{i+1,j}}{(\Delta x)^2} + \frac{T_{i,j-1} - 2T_{i,j} + T_{i,j+1}}{(\Delta y)^2} \right) \Delta t \]
2D Compute-to-Communicate Ratio

**Intracore** computing

**Intercore** communication

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

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

The 2D Compute : Communicate ratio is sometimes referred to as **Area-to-Perimeter**
3D Heat Transfer Equation

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

\[ \Delta T_{i,j,k} = \left( \frac{k}{\rho C} \right) \left( \frac{T_{i-1,j,k} - 2T_{i,j,k} + T_{i+1,j,k}}{(\Delta x)^2} + \frac{T_{i,j-1,k} - 2T_{i,j,k} + T_{i,j+1,k}}{(\Delta y)^2} + \frac{T_{i,j,k-1} - 2T_{i,j,k} + T_{i,j,k+1}}{(\Delta z)^2} \right) \Delta t \]

\[ \frac{\Delta T}{\Delta t} = \frac{k}{\rho C} \left( \frac{\Delta^2 T}{\Delta x^2} + \frac{\Delta^2 T}{\Delta y^2} + \frac{\Delta^2 T}{\Delta z^2} \right) \]
3D Compute-to-Communicate Ratio

Compute : Communicate ratio = $N^3 : 6N^2 = N : 6$

where $N$ is the dimension of compute nodes per core

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