The Compute : Communicate Ratio

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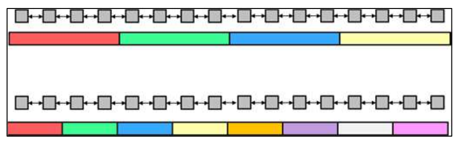
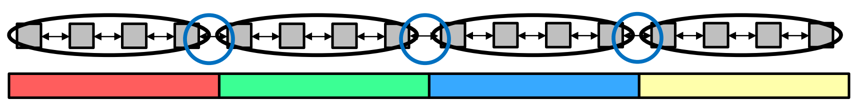


1D Compute-to-Communicate Ratio



Intracore computing

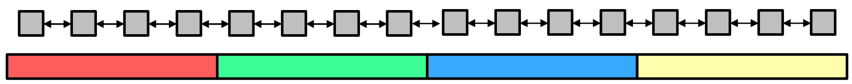
Intercore communication

Compute : Communicate ratio = N : 2

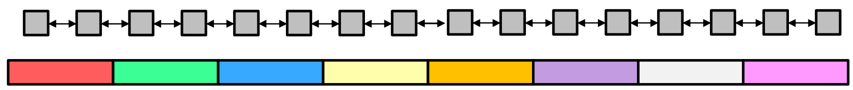
where N is the number of compute cells per core

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



In this case, with 8 cores, Compute : Communicate = 2 : 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.

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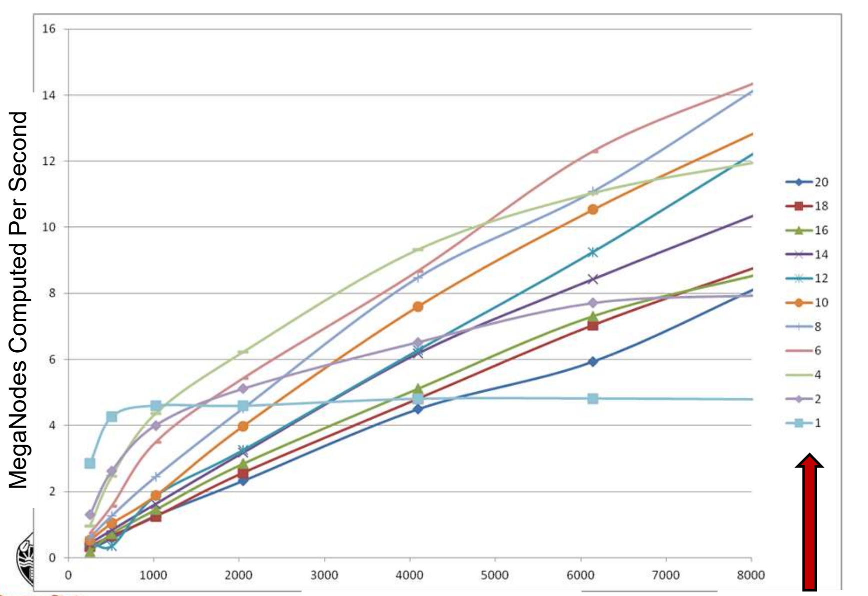
It's difficult to find the "sweet spot" without running experiments

Performance as a Function of Number of Nodes



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Performance as a Function of Number of Threads

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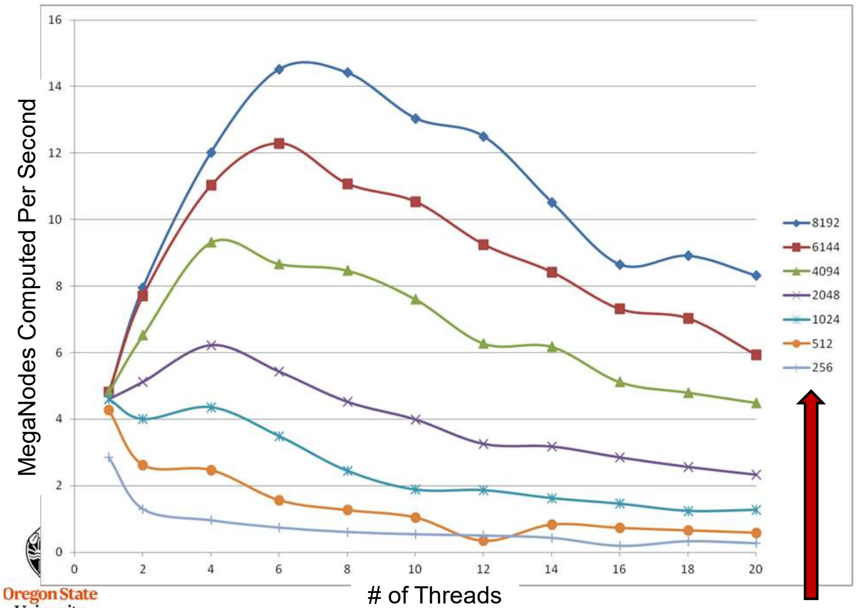

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2D Heat Transfer Equation

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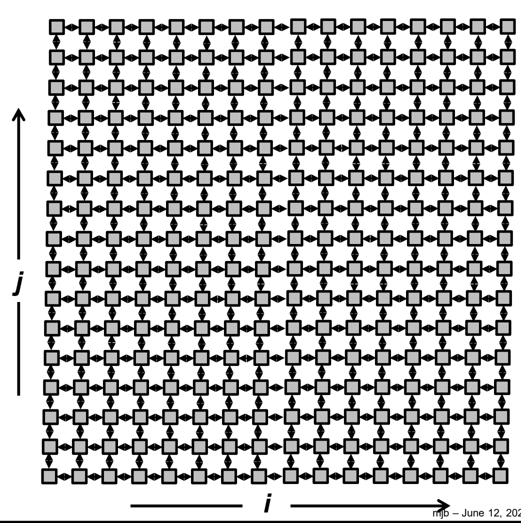
$$\rho C \frac{\partial T}{\partial t} = k(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2})$$

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

$$\frac{\Delta T}{\Delta t} = \frac{k}{\rho C}(\frac{\Delta^2 T}{\Delta x^2} + \frac{\Delta^2 T}{\Delta y^2})$$



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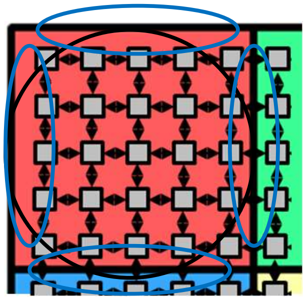
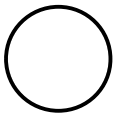
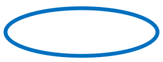
2D Compute-to-Communicate Ratio





Intracore computing



Intercore communication

Compute : Communicate ratio = N^2 : 4N = N : 4

where N is the dimension of compute nodes per core

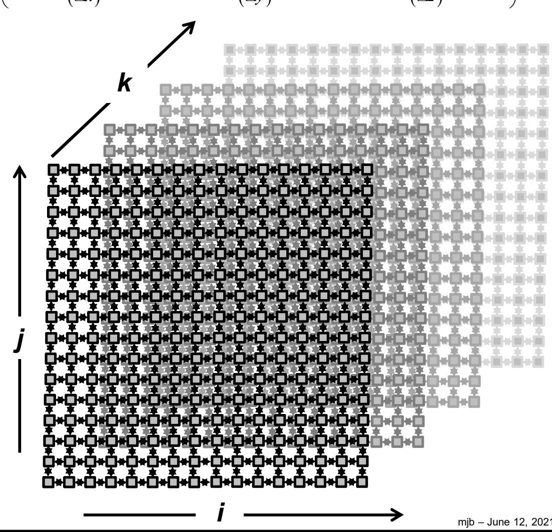
The 2D Compute : Communicate ratio is sometimes referred to as *Area-to-Perimeter*

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*