

The Compute : Communicate Ratio

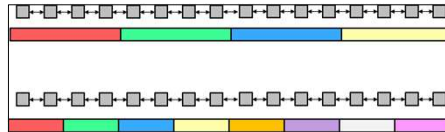


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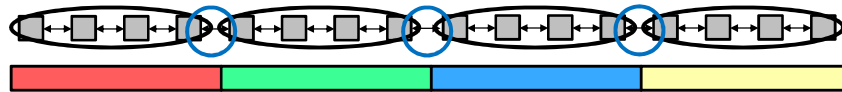
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compute_communicate_ratio.pptx

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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

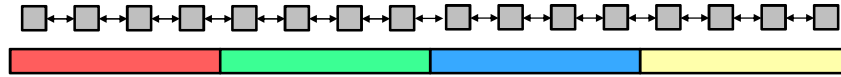


In the above drawing, Compute : Communicate is 4 : 2

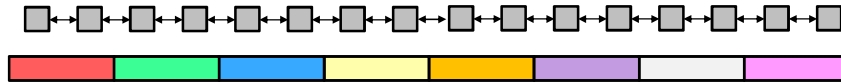
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How do more Cores Interact with the Compute-to-Communicate Ratio?

3



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



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

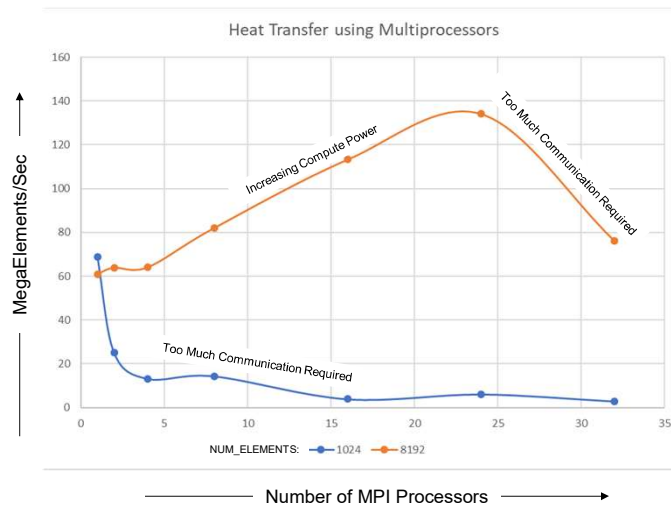


It's difficult to find the "sweet spot" without running experiments

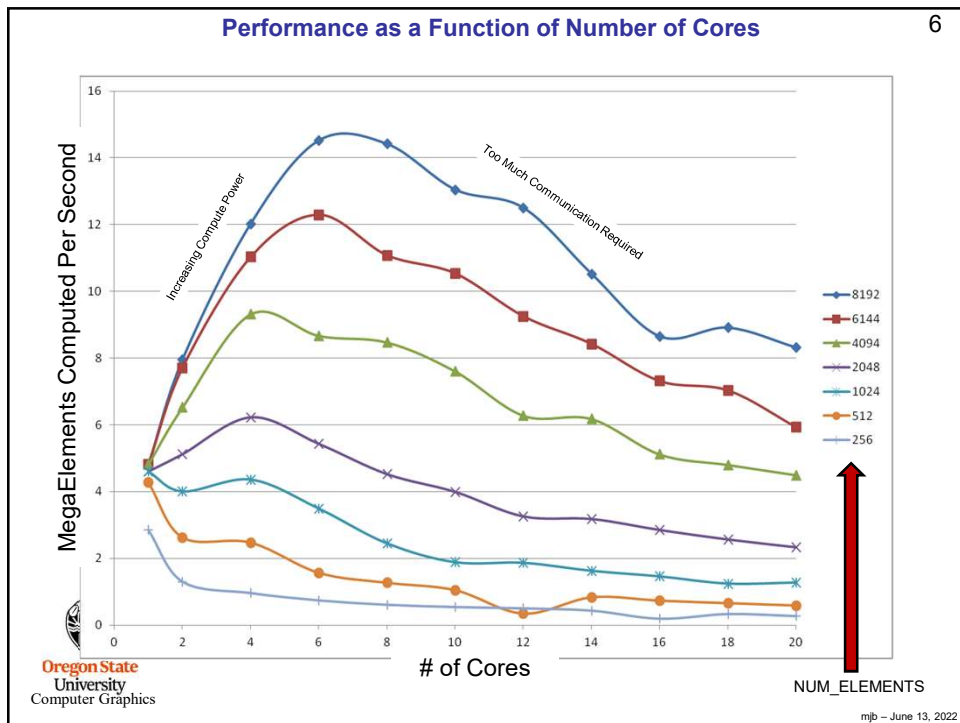
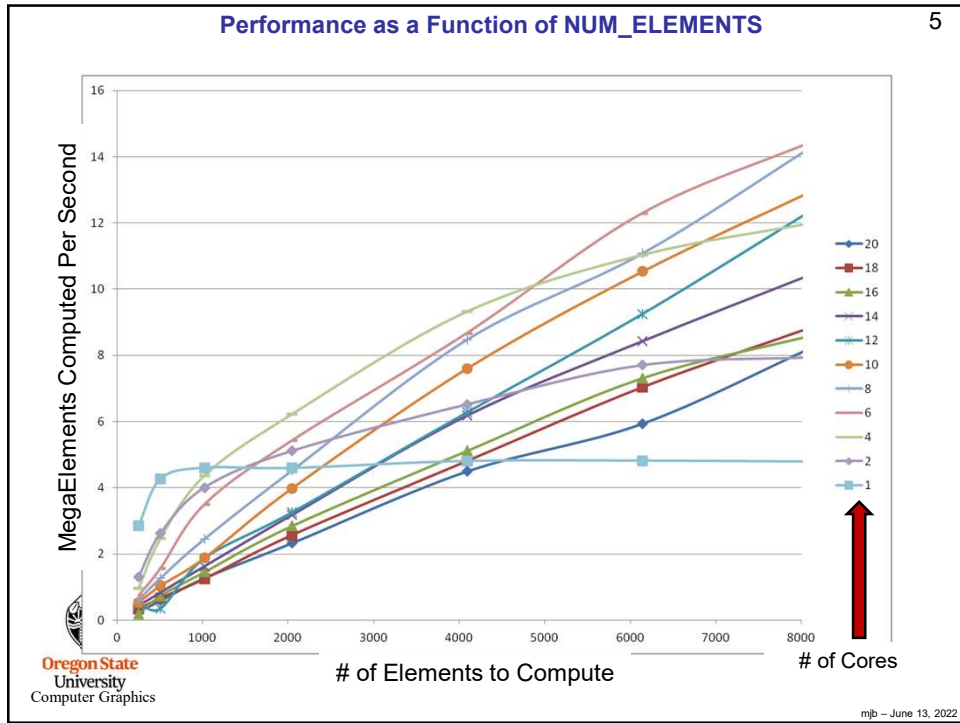
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Performance as a Function of Number of MPI Processors

4



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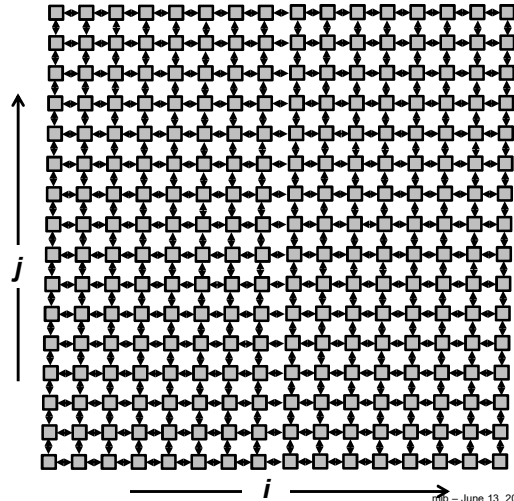
2D Heat Transfer Equation

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

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

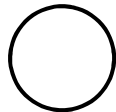
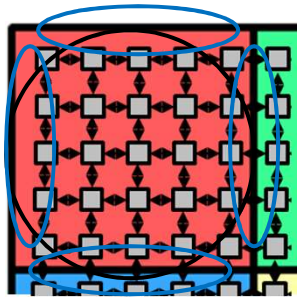
$$\frac{\Delta T}{\Delta t} = \frac{k}{\rho C} \left(\frac{\Delta^2 T}{\Delta x^2} + \frac{\Delta^2 T}{\Delta y^2} \right)$$



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2D Compute-to-Communicate Ratio

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Intracore computing



Intercore communication

$$\text{Compute : Communicate ratio} = N^2 : 4N = N : 4$$

where N is the dimension of compute nodes per core



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

Computer Graphics

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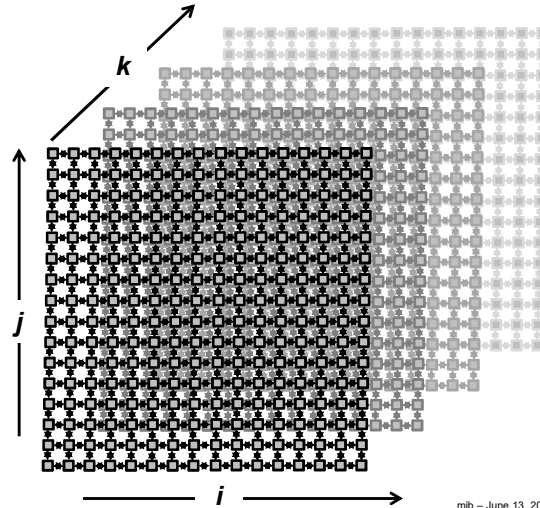
3D Heat Transfer Equation

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

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

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



3D Compute-to-Communicate Ratio

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$$\text{Compute : Communicate ratio} = N^3 : 6N^2 = N : 6$$

where N is the dimension of compute nodes per core

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