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Parallel Computing

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Session 7: Topologies, MPI Stencil

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Interconnect Topologies: Metrics

Topology Structure Properties

Topology	Degree	Diameter	Bisect. BWidth	Links	Nodes
Binary Tree	3	$2\log_2((N+1)/2)$	B	N-1	N
2-d Torus	4	$\sqrt{N}$	$2\sqrt{N}\,B$	2N	N
k-d Hypercube	k	k	$NB/2$	k x 2^{k-1}	2^k

Assuming balanced tree and binary hypercube

Stencil Operations

Stencil applications cure cancer.

Stencil applications make us understand outer space.

Stencil applications are used by your favorite let’s player

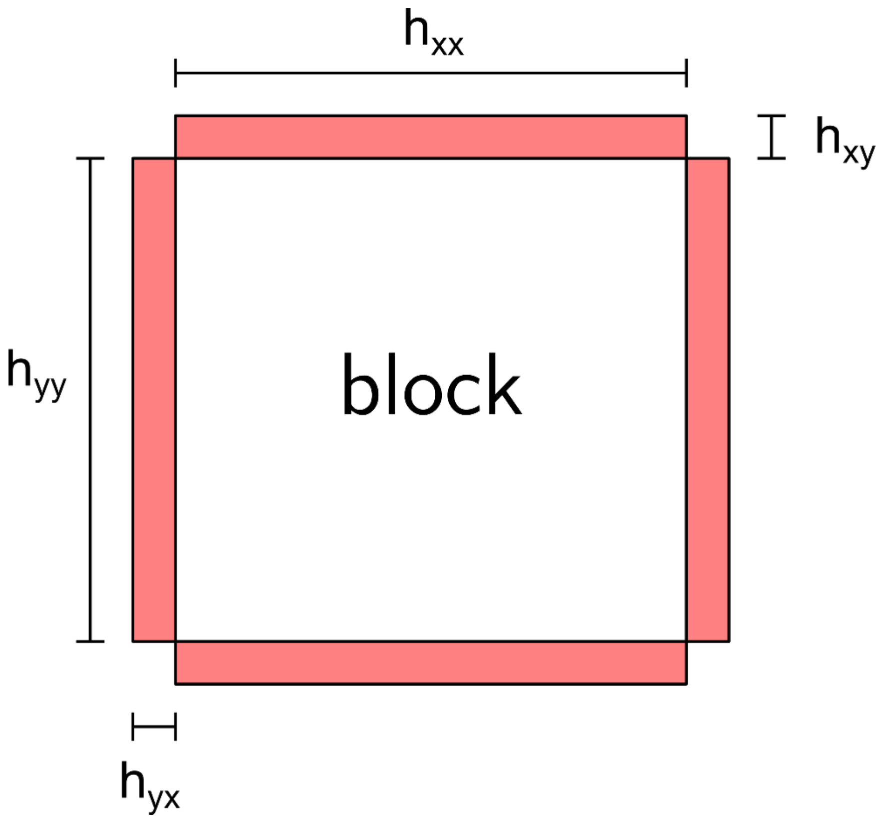
Stencil applications want to be friends.

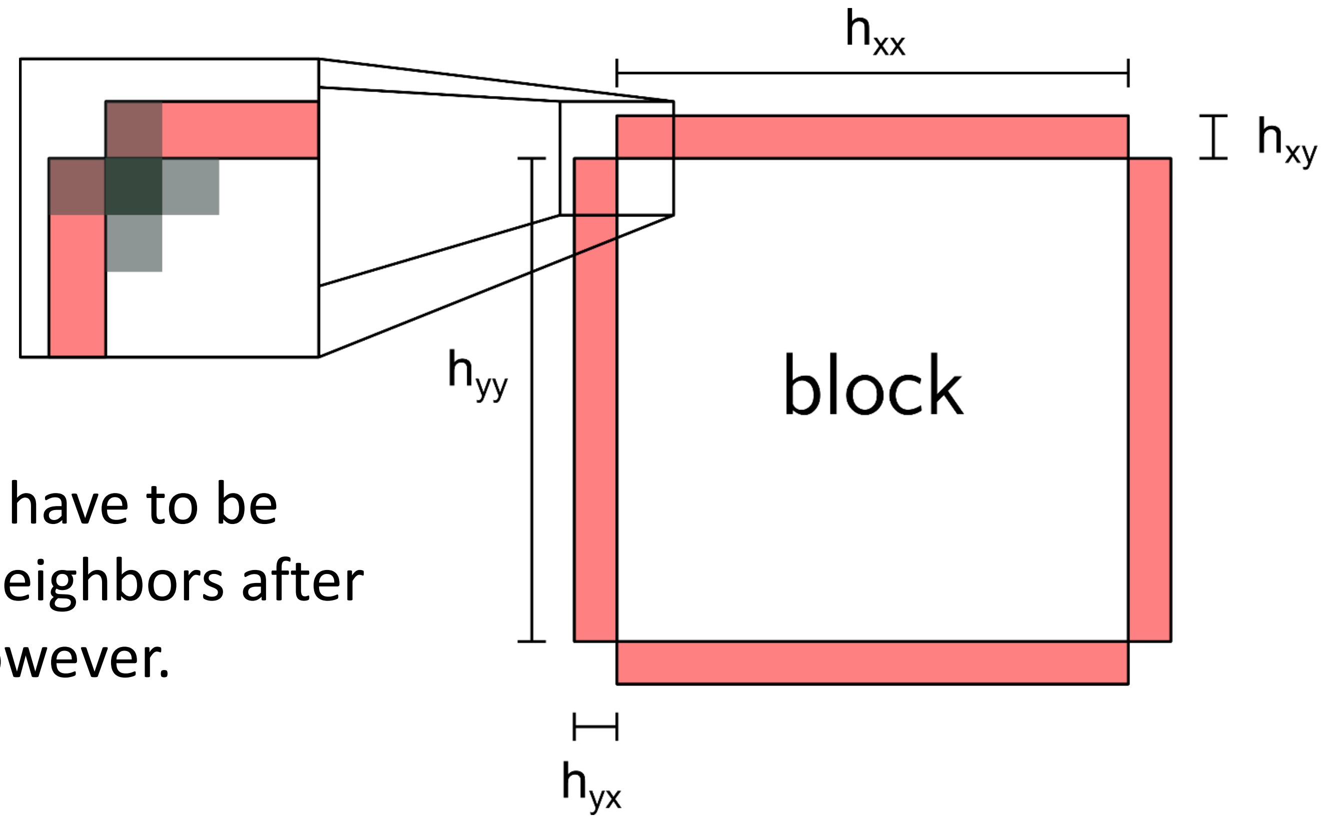
… Stencil applications mine altcoins.

rank 0 block [0,0]	rank 1 block [0,1]
rank 2 block [1,0]	rank 3 block [1,1]

Stencil Algorithms using MPI

Computing the inner-most values in a local block is straight-forward (local-only).





Ghost cells (halo) have to be exchanged with neighbors after each iteration, however.

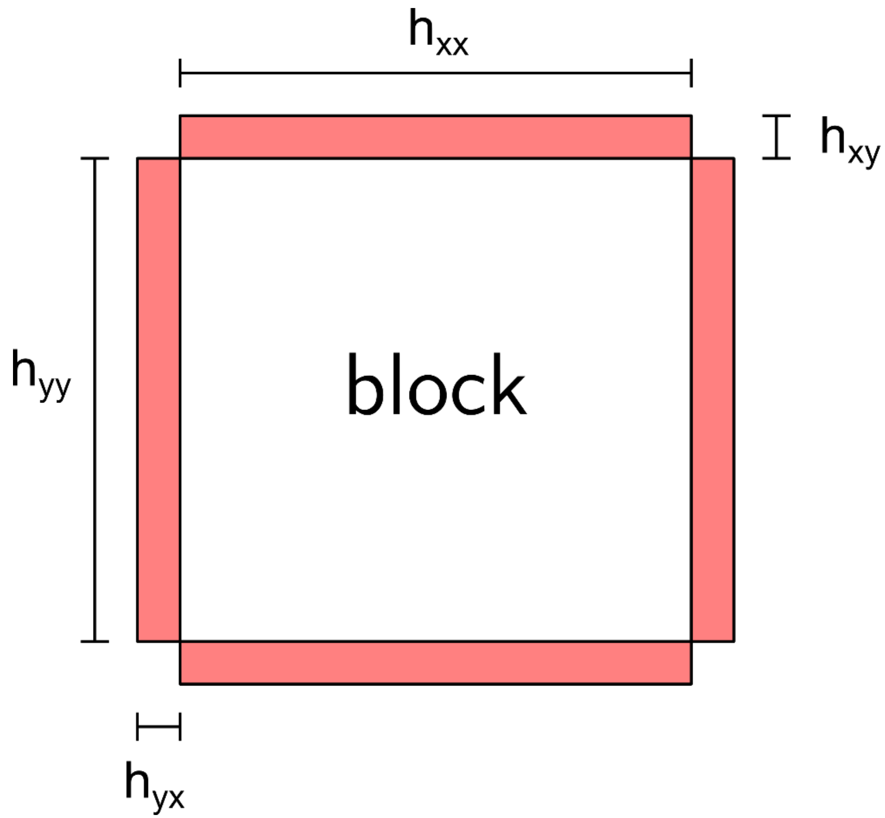
Assuming a 1-nn stencil,

block size $B = b_x \times b_y$

field size $N = n_x \times n_y$

Elements exchanged with all neighbors per block:
$4b_xb_y$

Surface-to-volume ratio?



Surface/Volume Ratio

- For high degree of parallelism: **select small block size** (more processes → more blocks → smaller block size)
- But: small block size affects border exchanges, surface/volume ratio increases.
- As the size of a block increases its **volume grows faster than its surface area**.
  Square-Cube Law: O(n3) vs O(n2)
- High ratio → more the time spent on communication per iteration, less time left to spend on actual computations.

Further Reading

The one MPI tutorial you all want to read:

Basics: https://cvw.cac.cornell.edu/MPI/
P2P: https://cvw.cac.cornell.edu/MPIP2P/
RMA: https://cvw.cac.cornell.edu/MPIoneSided/
Advanced: https://cvw.cac.cornell.edu/MPIAdvTopics/

Official MPI 3.1 documentation (Index):
http://www.mpi-forum.org/docs/mpi-3.1/mpi31-report/mpi31-report.htm#Node0

Again, a collection of documented MPI examples:
http://www.mcs.anl.gov/~thakur/sc14-mpi-tutorial/

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