

AstroBEAR2.0 and its Performance on Blue Gene/Q

Baowei Liu, Jonathan J. Carroll-Nellenback
Center for Integrated Research Computing

Abstract

AstroBEAR is an Adaptive Mesh Refinement(AMR), multi-physics parallel code for astrophysics. AMR remains at the cutting edge of computational astrophysics. AMR simulations adaptively change resolution within a computational domain to ensure that the most important features of the dynamics are simulated with highest accuracy. By allowing quiescent regions to evolve with low resolution, AMR simulations achieve order of magnitude increases in computational speed. Current AMR simulations require algorithms that are highly parallelized and manage memory efficiently. Here we present both the AMR and parallelization algorithm used in the AstroBEAR 2.0 code. We also present the scaling test and optimization results of AstroBEAR on our flagship, the new Blue Gene/Q at CIRC.

Adaptive Mesh Refinement

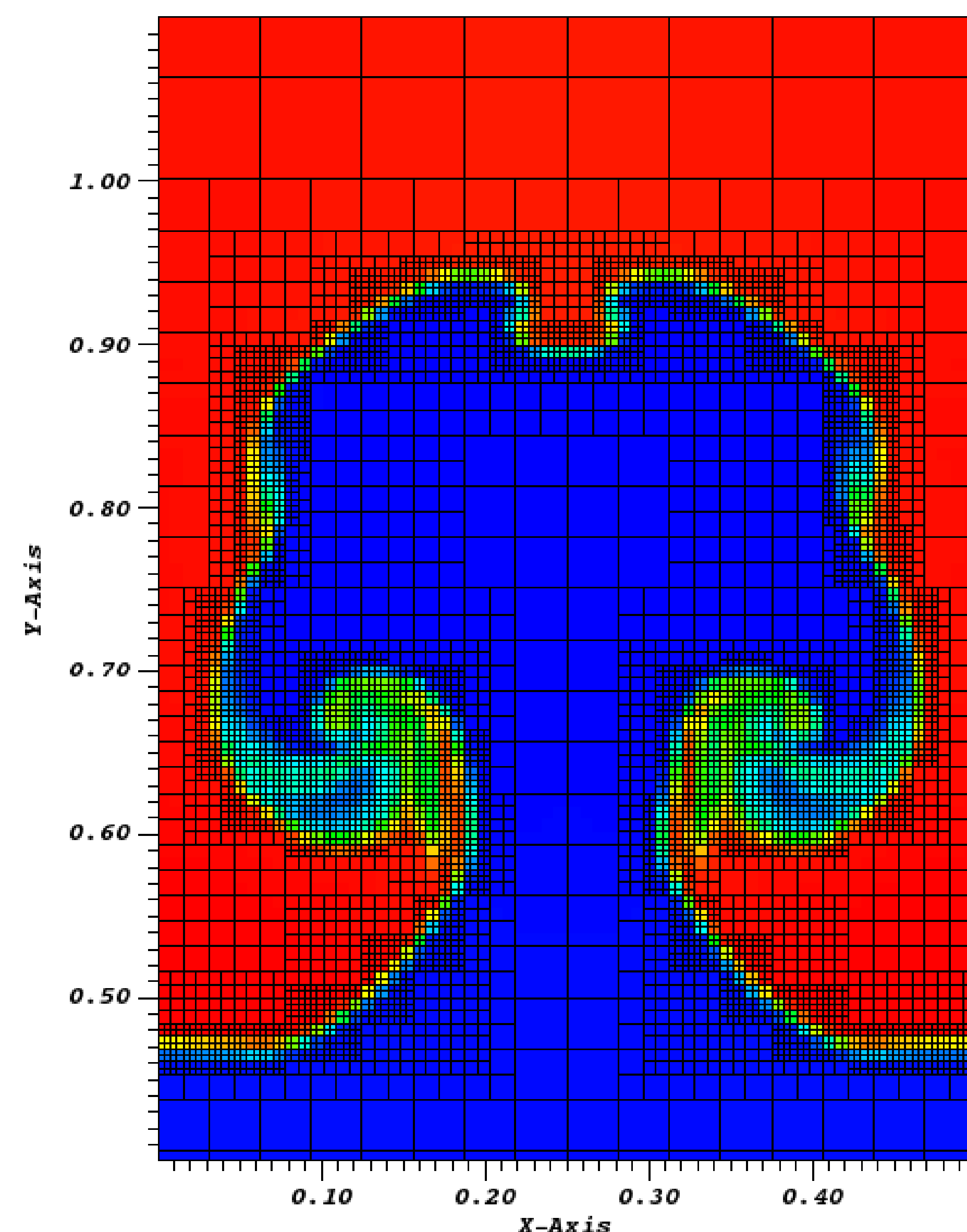


Figure 1: Grids showing 2-level AMR. Generated with 2D RTInstability module of AstroBEAR2.0



<http://astrobear.pas.rochester.edu>

Distributed Tree and Level Threading

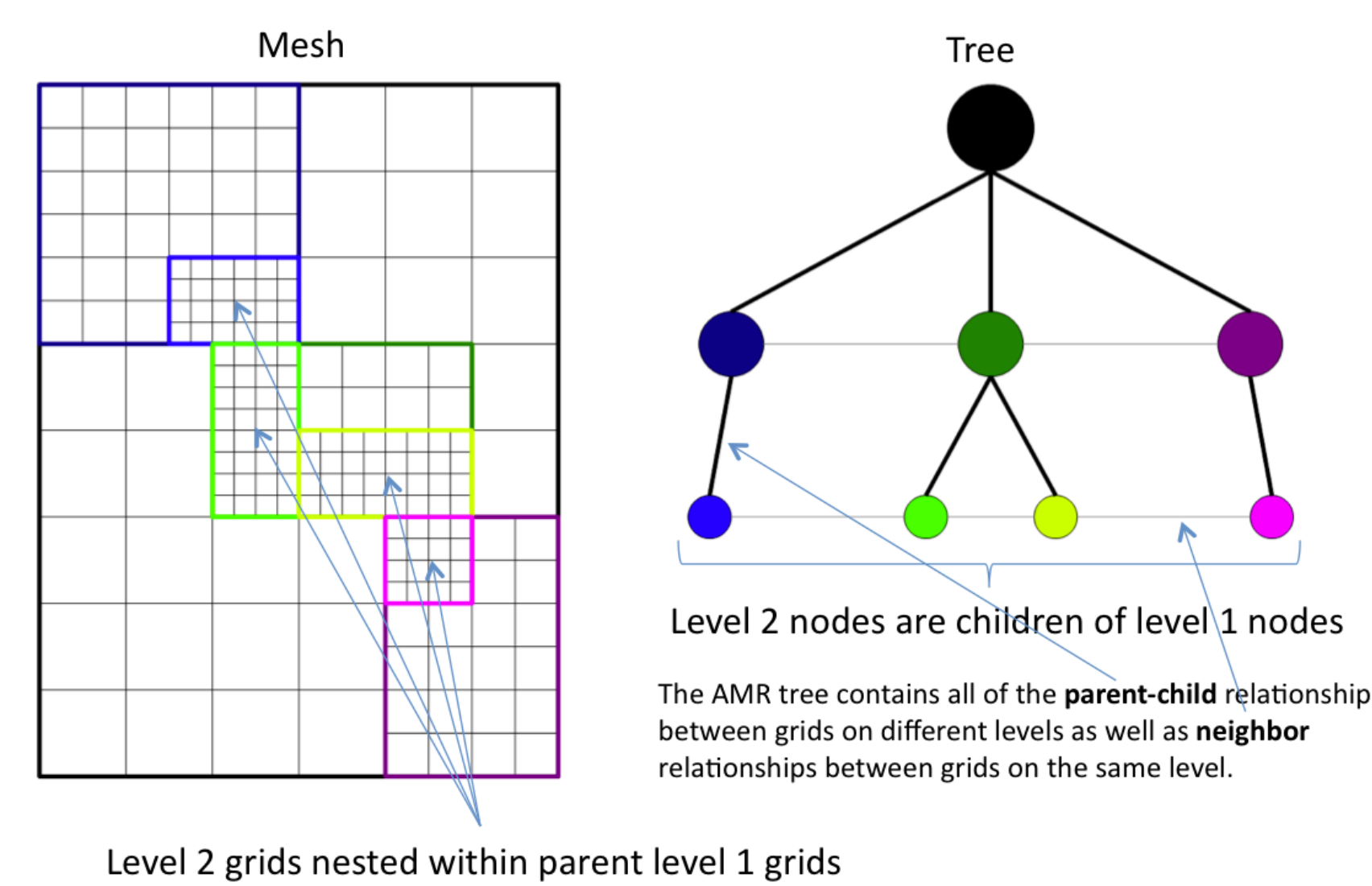


Figure 2: Hierarchical AMR tree in AstroBEAR2.0. The tree changes each time new grids are created by their parent grids. The nodes corresponding to these new grids have to be added to the tree and connected to the overlaps, neighbors and parents.

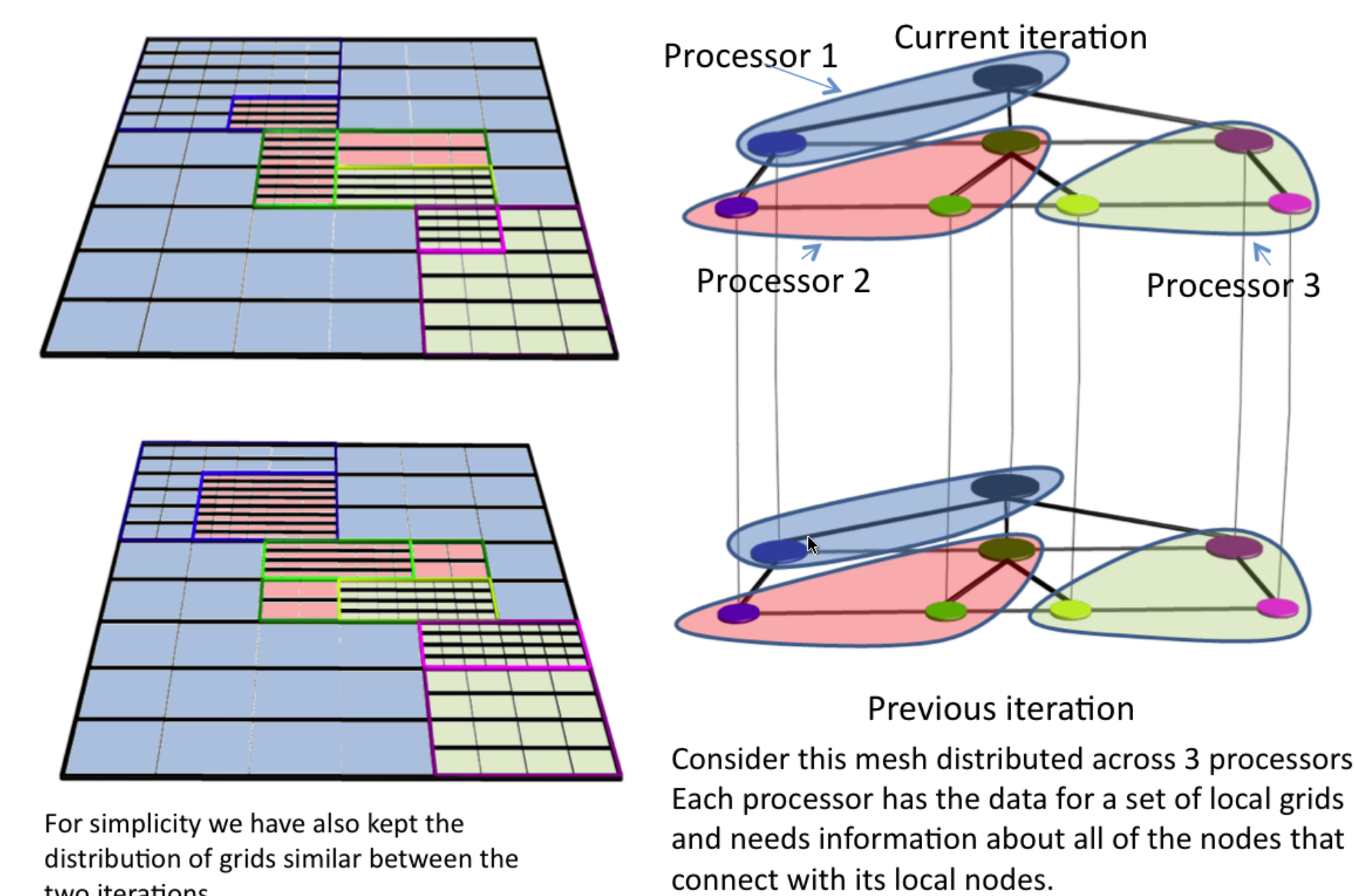


Figure 3: Distributed tree in AstroBEAR2.0. Nodes contain the meta-data that includes the physical location of the grid and the processor containing the grids data. So large-scale patches of data are distributed to computing nodes using MPI. This technique makes AstroBEAR code highly parallelized and able to manage memory efficiently.

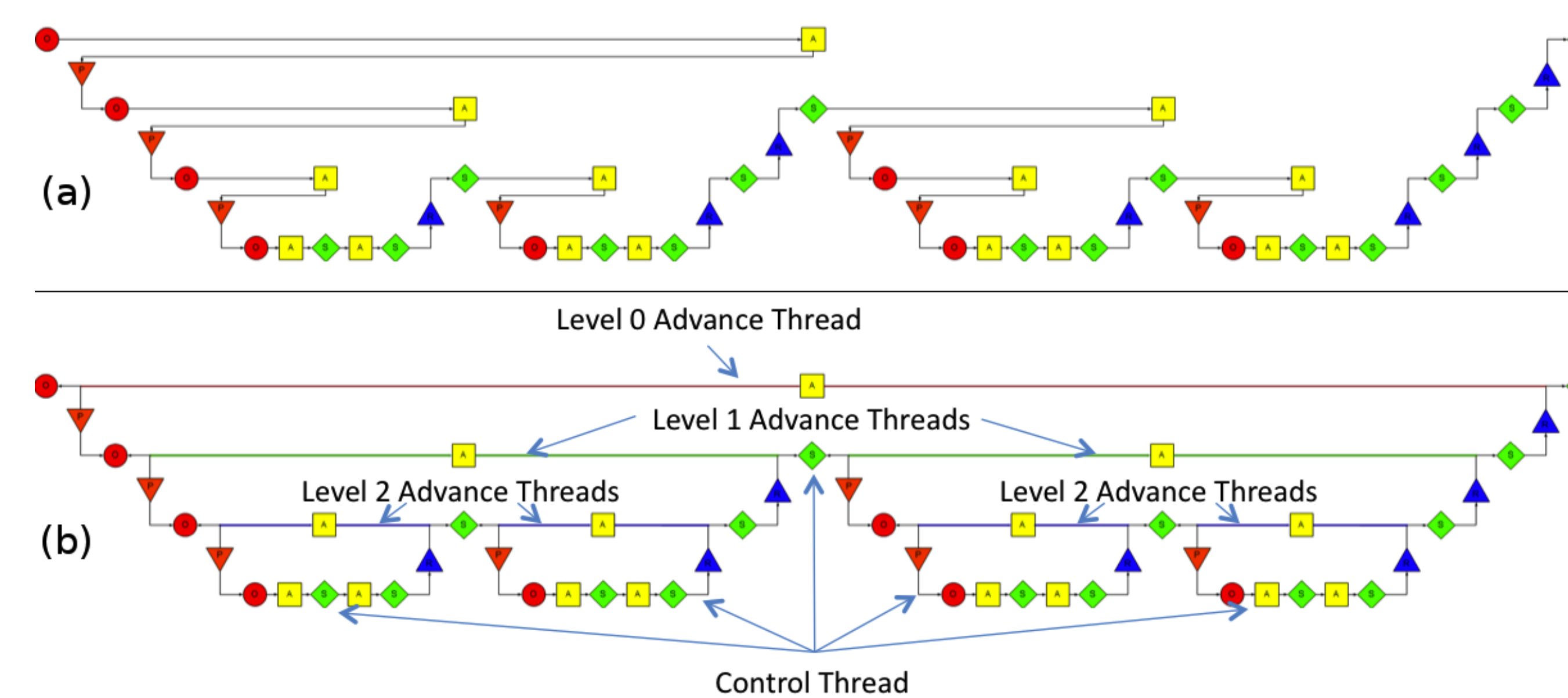


Figure 4: Level threading in AstroBEAR2.0 (a) serial execution; (b) threaded execution. Level threading uses multi-threads to do Advance, Prolongation, Synchronization and Restriction for each level of AMR so it brings extra parallelization to the code.

Scaling Test Results on BlueStreak

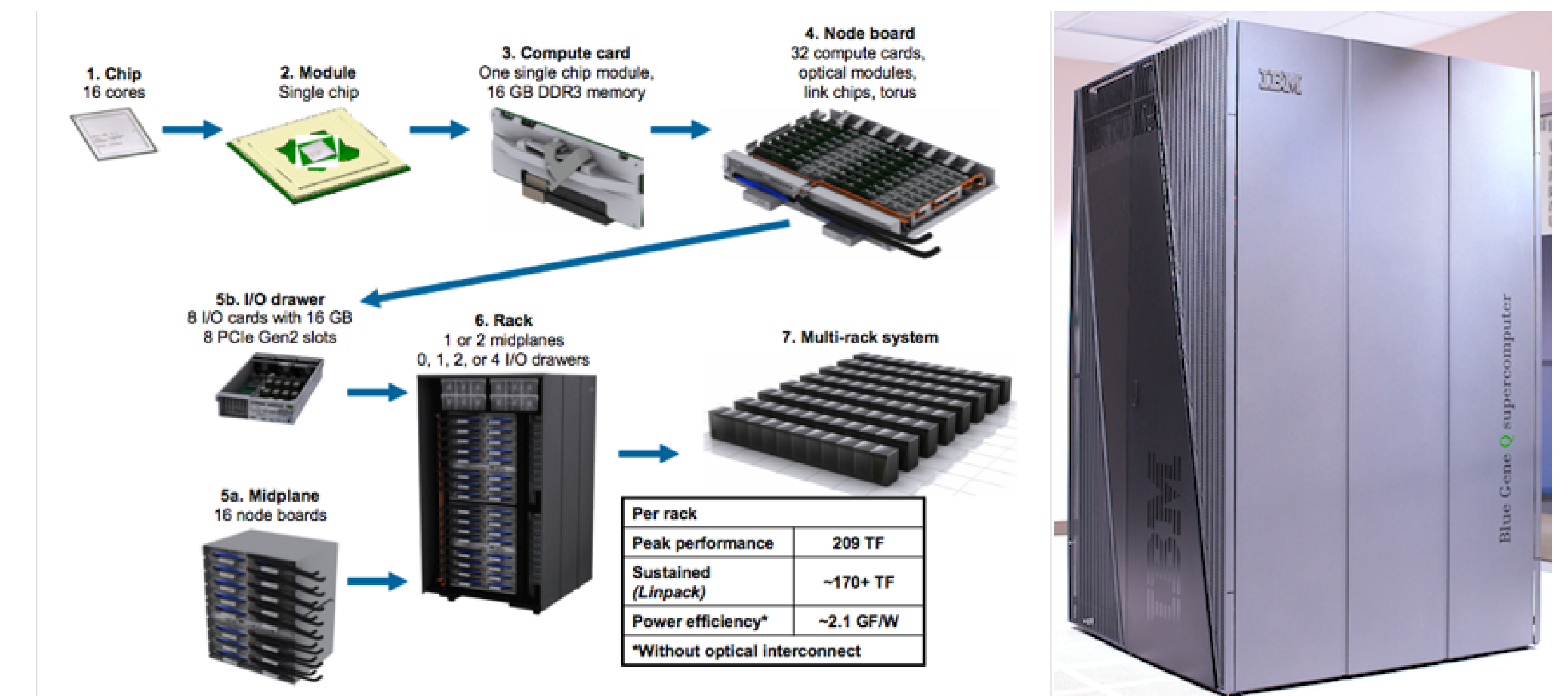


Figure 5: The Blue Gene/Q system at the University of Rochester: BlueStreak. It consists of 1,024 nodes, 16,384 CPU cores, 16 TB of RAM, and 400 TB of storage.

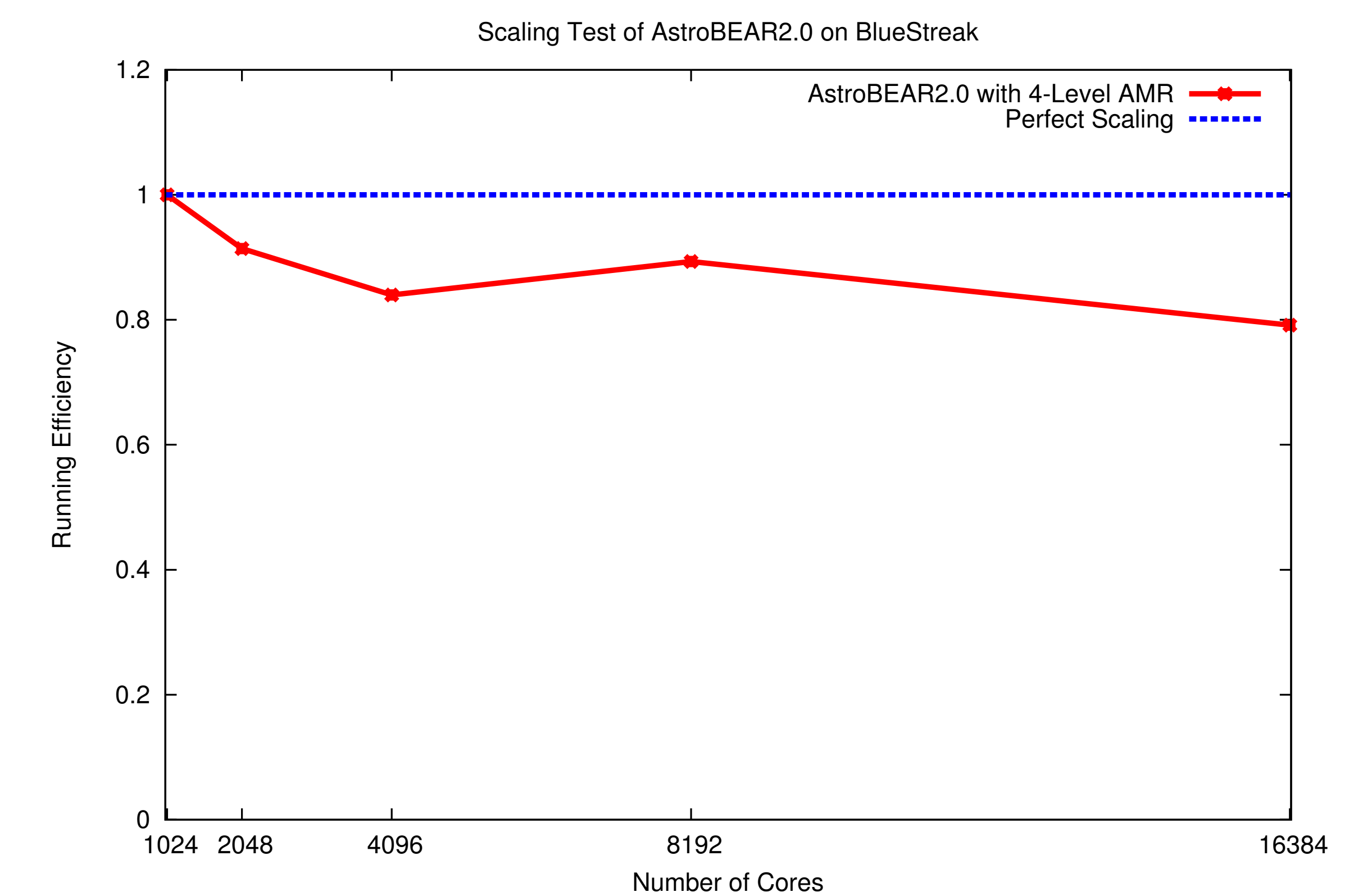


Figure 6: Scaling Test of AstroBEAR2.0 on BlueStreak. The running efficiency of AstroBEAR only goes down about 20% when running on the whole BlueStreak machine (16384 processors).

Conclusion

AstroBEAR is a multi-dimensional AMR MHD code developed by the UR Astrophysics group. Here we introduce the two key techniques – the adaptive mesh refinement(AMR) and parallelization algorithm with distributed tree and level threading in AstroBEAR2.0. We also show the excellent scaling test results of AstroBEAR2.0 on our new Blue Gene/Q system BlueStreak at the University of Rochester. These results tell us AstroBEAR2.0 are highly parallelized and manage memory efficiently.